Metals and Alloys

THE MAGAZINE OF METALLURGICAL ENGINEERING

PRODUCTION · FABRICATION · TREATMENT · APPLICATION

APRIL 1942

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Feature Articles

Permanent Magnets—A Foundry Product

Permanent magnets—made of complex steels or special alloys and treated to provide unique electrical and magnetic properties—are foundry products that are playing an essential part in communication systems and other electrical applications. J. H. Goss (page 576) discusses their manufacture, design and properties, with special attention to Alnico.

Reference Table for Foundrymen

H. R. Clauser (page 583) has compiled a handy reference table that gives in one place the solidification ranges, shrinkage factors and specific gravities of a large number of metals and alloys commonly produced as castings.

Lead-Base Babbitts to Save Tin

American engineers must now realize that tin uses will have to be drastically curtailed and tin-alloy bearings will be quick to feel the pinch. H. W. Gillett and R. W. Dayton (page 584) announce and discuss new *lead*-base babbitts containing silver that promise to be satisfactory substitute for the high-tin alloys.

Fabricating Copper Steels

The corrosion-resistant copper-bearing steels would be even more widely used than they are for heavy pressure vessels, stills, etc. were it not for a tendency to surface cracking when welded or otherwise heated in fabrication. F. Eberle (page 588) discusses the condition and suggests some practical remedies.

Brake Drums

Oliver Smalley (page 595) concludes his useful engineering discussion of brake drum materials with an analysis of thermal checking conditions.

Malleable Beryllium

Many engineers have felt that they could use beryllium metal for certain applications—"windows" in X-ray tubes, for example—if it were only malleable. According to G. E. Claussen & J. W. Skehan (page 599), the metal can now be produced in malleable form by the procedure outlined by them in this article.

Foundry Show Preview

The A. F. A.'s April 20-24 "Western Hemisphere Foundry Congress"—a combined technical convention and exposition—is previewed in this issue, starting on page 607.

Metallurgical Engineering Digests

Centrifugal Casting of Guns

The history of big-gun manufacture has included a cast-iron age and a steel forging age. We are now in the centrifugal steel casting, or World War II, period. Case (page 648) describes modern centrifugal casting practice as employed at Watertown.

Machining Cannon Rifling-Grooves

Perfect rifling accuracy and internal finish of cannon depend on correct machining practice. Several different methods in use for machining cannon rifling grooves are described and their merits compared by Safford (page 660) in an informative review.

Hollow Steel Propeller Blades

Modern hollow steel aircraft propeller blades as made by Lycoming involve several unique and interesting metal-design and processing steps in their manufacture (for example, simultaneous quenching and forming in metal dies, to mention only one). All are described by Reiber (page 665).

Cartridge Case Drawing, Annealing

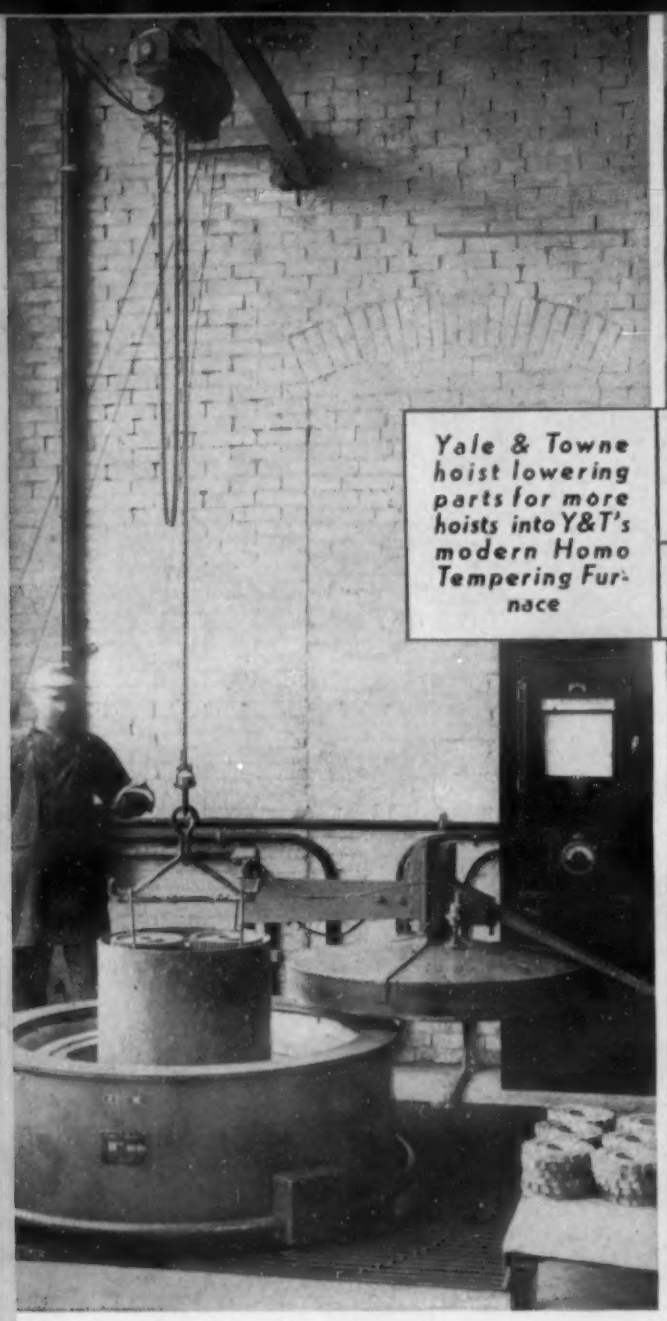
For the brevity of their service lives, cartridge cases certainly undergo a long cycle of operations in their production, which is described by Nealey (page 666).

Metallizing Aircraft Engine Parts

Production metallizing—as distinct from *maintenance* work—got a big boost when Wright switched from aluminum paint to sprayed molten aluminum as a protective coating for aero engine components. The cycle of operations is described by Linsley (page 674).

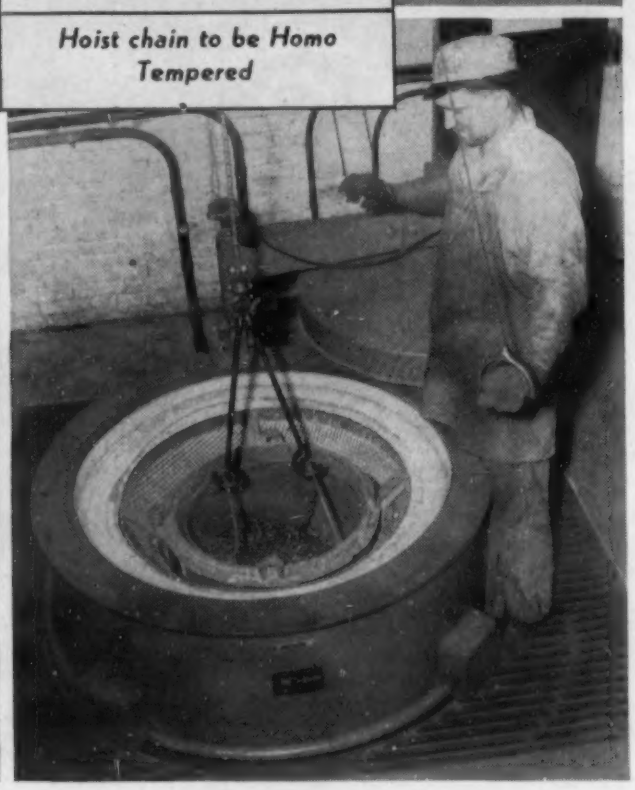
Bearings That Can Take It

Bearings for "heavy duty" automotive engines (about the only kind we'll be producing for a long, long while) present many design and material-selection problems for engineers, one gathers on reading Willi's survey (page 684) of bearing types and their performance.



Yale & Towne hoist lowering parts for more hoists into Y&T's modern Homo Tempering Furnace

Typical gears, yokes and shaft Homo-Tempered for Yale & Towne hoists and trucks



Hoist chain to be Homo Tempered

"GLAD WE HAVE HOMO TEMPERING FOR WAR WORK" Says Yale & Towne

Faced with ever-increasing production, Yale & Towne's truck-and-hoist plant recently decided the time had come for Homo Tempering of the heat-treated parts of their products. They selected, accordingly, an equipment which includes a furnace with work space of 21.75 x 48", and are now tempering all their "small" parts by the Homo Method.

Production figures, even if available, would be hard to interpret, because the work varies greatly. But forgings, stampings, castings and welded parts go through the furnace in quick, unbroken succession. And the work is handled in any desired order of temperature. A batch at 700 F may be followed immediately by others at 375, 650, etc. Still others may go to 1400 F. And there's never been a reject charged to Homo Tempering.

Workers at Yale & Towne like the Homo. It is so clean; so safe; so fully automatic that loading and unloading is the only attention it requires. Heavily insulated, it stays cool on the outside. Its automatically drawn record shows the work done, and done correctly. Men and management have a "tool" for doing an important job, exactly as directed.

For completely-illustrated description of the Homo Method, with sizes, etc., of equipment, see Catalog T-625, sent on request.

$800 Per Month Saved By Homo Carburizing Of Bearings And Cones

A company which makes large quantities of inexpensive ball bearings recently stopped pack carburizing in favor of the Homocarb Method. Good results and few rejects were expected, but, in addition, the overall cost of running the heat-treat dropped just $800 per month when the change was made to Homocarb! The furnace has a work space of 20x26". Complete with controller, slow cooler, and all accessories, it paid for itself in only 9 months.

Homocarb is a cost-saver, production-increaser in many ways. The parts require neither packing nor unpacking. And they can be quenched directly from the furnace, or slow-cooled, as desired. The carburizing medium is completely consumed—no chance for a slip in adding make-up. It is of known, guaranteed carburizing power. It is added to the work in precisely-controlled amount. The temperature is automatically held at the correct point, for the desired time. And, with these factors under complete, coordinated control, there's really no reason why a competent heat-treating department shouldn't get fine results. Homocarb does its full share; the user does his; and together they save time, work, space and rejects. See Catalog T-623, or put your problem directly up to us.

The Homocarb equipment which is saving $800 per month is the same type and size as that pictured above, which happens to be one of a battery in an aircraft plant.

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After the War

It is too early to predict conditions after the war but certain trends are already being recognized which point the way to some changes that may be permanent. Among the radical ones, due to scarcity of metals, may be mentioned the following:

It is fairly well established that lead-base babbitts or bearings can be made satisfactorily efficient so as to take the place of the tin-base materials if certain modifications of composition are made, such as the addition of silver, copper or some other metal. An article in this issue by Gillett and Dayton is a case in point. Also it has been demonstrated that the conventional tin solders can be modified by the judicious use of silver or other metals in place of some and more probably of all or nearly all of the tin with very little sacrifice in workability. And these are not all the solutions of various tin problems.

The scarcity of several of the metals in the general run of alloy steels has given rise to what amounts to a revolution in our conception of these steels. We are learning that simpler compositions, properly heat treated, can meet many if not all of the demands of the more complex steels. It is not an unreasonable expectation that many of these steels, such as those coming under the NESS, will continue to be used even after the present scarcity of certain alloying metals disappears. It may even be stated that we are learning so much about the heat treatment of carbon steels that these will have applications not familiar before the war.

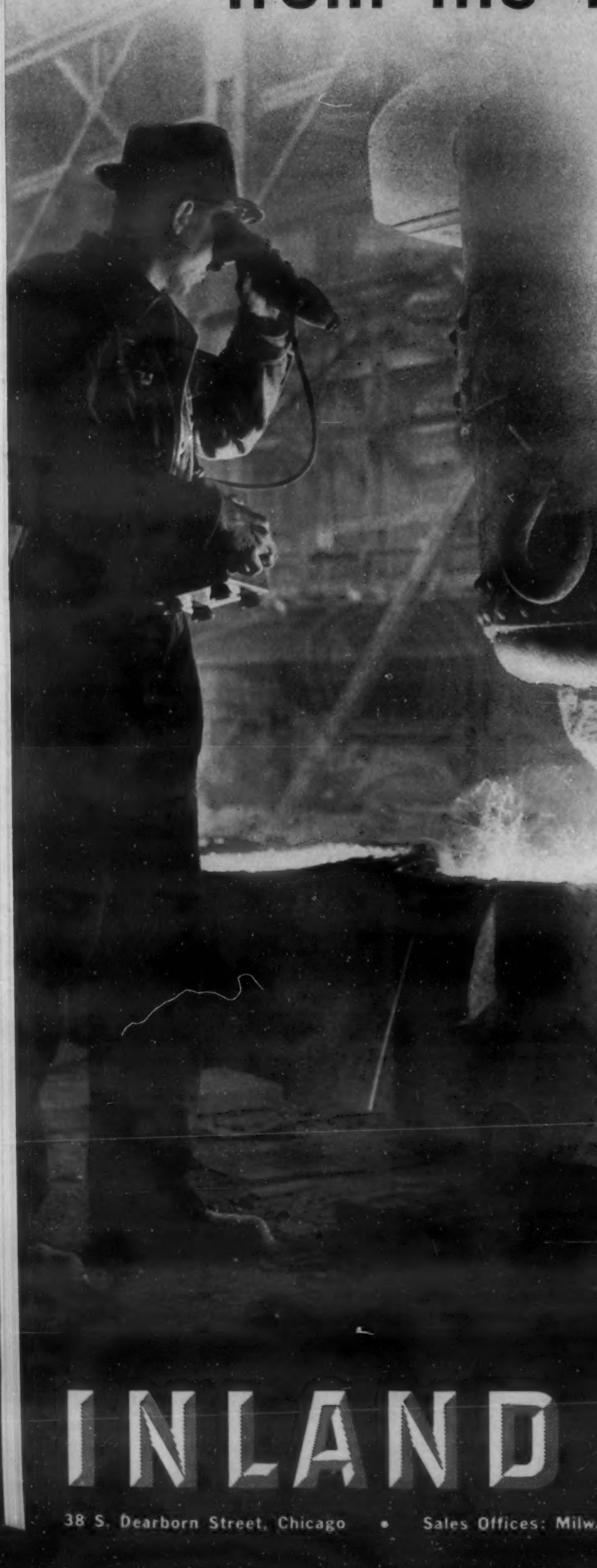
And then finally our knowledge of what can be accomplished by heat treatment is being decidedly broadened so that by variations in temperature, quenching, drawing and so on, properties are being developed in both the complex and the simpler steels which are of great value and which will probably endure. A case in point is the successful heat treatment of an 85,000-lb. steel casting by quenching in water and drawing — a practice regarded as perilous not long ago.

Examples such as the foregoing could be multiplied. Those cited above, however, demonstrate that the post-war period will experience many changes in pre-war practice which will not only cut down much of the waste of the earlier days, but also will simplify our practice with no sacrifice of quality.

—E.F.C.

(Continued on page 575)

Better Steels Are Coming— from the Tests of War



Out of today's grueling war tests are coming better steels for tomorrow. In Britain, Russia, North Africa, and the Far East equipment built of American steel is setting new performance and endurance records.

But, we have not yet come to the end, for world-wide battle tests are pointing the way to new requirements that are being met in the laboratories and the steel mills of America.

Inland is actively taking its place in this new phase of the steel age. Before World War II Inland gave to industry such valuable steel mill products as: high-strength Hi-Steel; fast machining Ledloy; finer cold reduced tin plate; etc.

Today, with greatly enlarged research facilities and the valuable experience of exacting wartime production, Inland is looking forward to meeting the steel needs of America at peace.

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Overdoing It

"Stress-rupture" tests have rather recently been added to the list of tests designed to evaluate the long-time performance of steels at high temperatures, with the implied hope that information on stability and long-time load-carrying ability may be extrapolated therefrom. The ability to carry load without unbearable deformation is primarily evaluated by creep tests taking a thousand hours, preferably several thousand, because the short-time high-temperature tensile test notoriously fails to give reliable information about small deformation over long periods.

Stress-rupture tests, carried out at unit stresses far above any possible design load, fall in between the creep test and the tensile test in that the initial deformation is relatively slow, but the specimen is finally carried to complete rupture. The stress-rupture results often indicate that a steel may stretch for a while and then grow brittle and fail by cracking. When this occurs it makes engineers jittery about using the steel at reasonable design loads, even when, as is the usual case, the steel thus evaluated as service-brittle doesn't really act that way in service at any load that would be contemplated in design.

Data recently reported from England, "Investigation of the behavior of Metals under Deformation at High Temperatures—Part 2, Structural Changes in Carbon Steels caused by Creep and Graphitisation", by Jenkins, Mellor and Jenkinson of the N.P.L., afford one explanation for failure of these over-load tests to tell a true story. The English investigators find that pearlitic carbon steels spheroidize very much more rapidly when they undergo very appreciable plastic deformation concurrent with elevated temperature. Study of their data clearly indicates that resistance to spheroidization that would be entirely adequate to provide safely long life at reasonable design loads, can be overcome by overloading and thus overstretching the steel. The picture is a trifle different when, instead of ordinary steel, we get into the wholly or partly austenitic highly alloyed materials in which precipitation effects can occur.

The stress-rupture tests may pick out cases where structural changes are going on, and lead to adoption of compositions or of stabilizing treatments that will minimize the precipitation effects. However, the facts about precipitation need to be learned by methods directly aimed to bring them out, so the stress-rupture data only act as one sign post.

From many points of view, stress-rupture tests remind one of salt-spray corrosion tests for material to be used in ordinary atmospheric exposure; they give information—which may be worth having, it is true—on what happens when you mistreat the material, but may be very misleading in respect to actual service behavior. We can't run the hundred in 10 flat, ourselves, but we can still follow the dogs all day in the hunting field. The value of knowing that we can't run the dash is so that we have sense enough not to try. —H.W.G.

It Is Later Than We Think

"Time as a Factor in the Making and Treating of Steel," the title of Dr. Johnston's recent Howe lecture, reminds us of the dominant part time is playing in this battle of production called World War II, and of the jolting shift that has occurred in much of our thinking about the relative importance of *now* and *the future* as part of the pattern of time.

Except for a few islands of alertness in a great sea of complacency, most Americans — including many metallurgical engineers, with

(Continued on page 604)

Permanent Magnets

by J. H. GOSS

Engineer, Works Laboratory, General Electric Co., West Lynn, Mass.

In war as in peace, such special-metal parts as contacts, bearings, transformer cores, resistors, permanent magnets, etc. are vital to the smoothest functioning of communications and other electrical equipment. All must be carefully chosen as to metallurgical nature and skillfully manufactured to bring out their best electrical properties. This article discusses permanent magnets—the alloys used, and the manufacturing methods (foundry and fabricating) generally employed—with especial attention to the Alnico type. —The Editors.

WITHIN THE PAST FEW YEARS, a number of new permanent magnet alloys have been developed. These alloys are characterized by greatly increased magnetic energy over alloys previously available and by lower raw material costs per unit of magnetic energy.

These new materials have given renewed impetus to designers of permanent magnets for a wide range of applications. The largest use in pounds is probably for radio loud speaker magnets and the second in size, magnets for electrical measuring instruments including watthour meters. These new materials require, however, a different production technique than was generally used for the older permanent magnet materials. This fact, combined with the inherently different magnetic characteristics, makes direct substitution of materials for existing designs, in general, impractical as will be discussed later in more detail.

Properties of the Alloys

The properties of 11 commercially available permanent magnet alloys are shown in the Table. To better illustrate the advantages of the newer materials over the most commonly used materials, which were used previously, (Alloy No. 1, chromium steel, and Alloy No. 2 tungsten steel) Fig. 1 has been plotted. This shows graphically the increase in energy value and the decrease in cost per unit of energy value of the newer materials as compared with the old. The energy value of a magnetic material is the maximum value of the product ($B \times H$) for the demagnetization curve.

It should be definitely understood that the cost of the magnetic material, as shown in Fig. 1, refers only to the alloy. The cost of the completed magnet from the high energy value materials may be considerably more than for the equivalent magnet made from chromium steel. The investment in equipment must also be carefully considered.

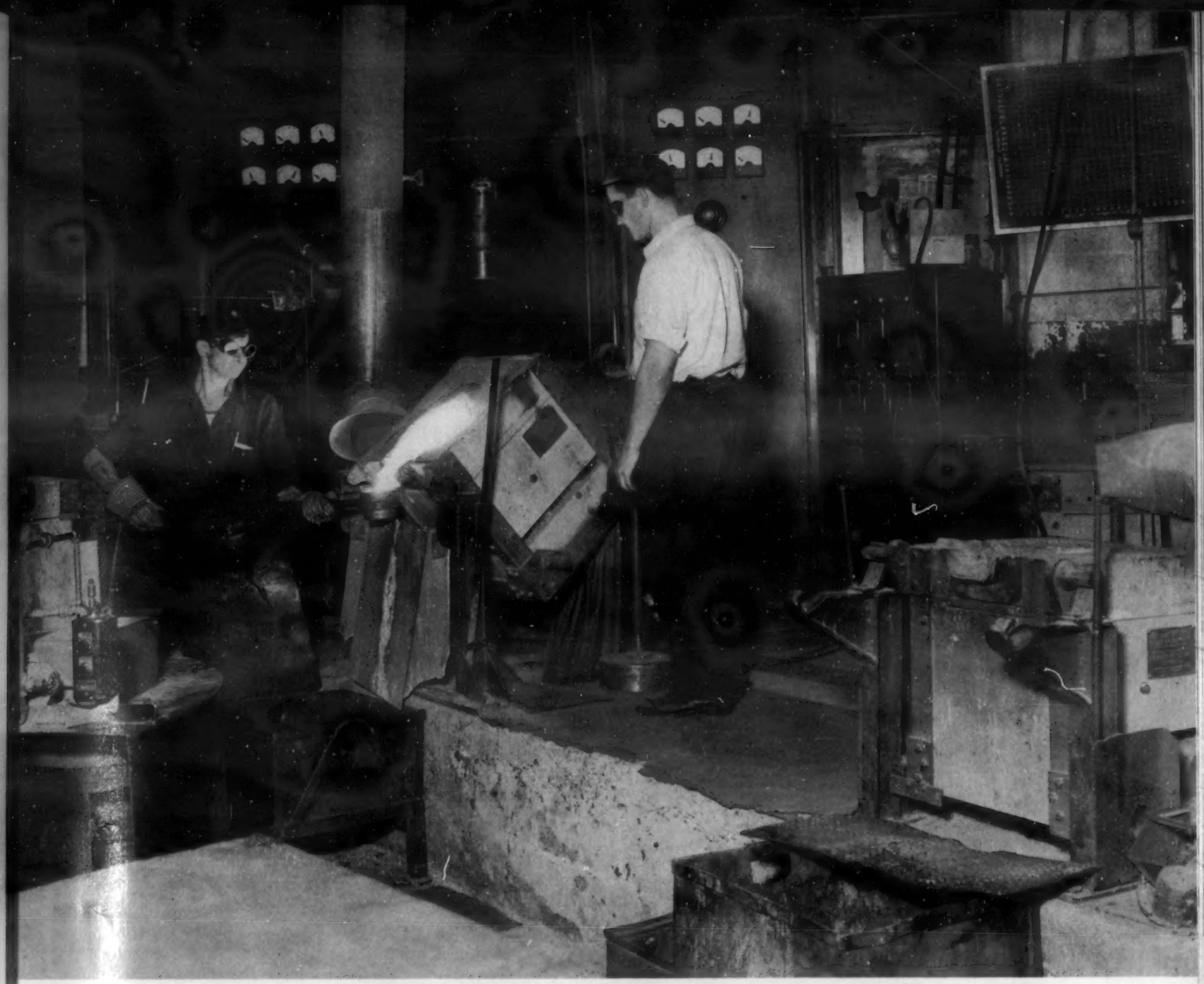
The decrease in space required, together with the lighter weight, may easily justify an increased permanent magnet cost. The permanent magnets with a high value of coercive force (H_c) are very resistant to demagnetizing fields and in some applications this is of prime importance.[2]

It is helpful in comparing these materials to keep in mind two design approximations that apply when considering the dimensions of a magnet to supply flux to a given air-gap. The essential dimensions are, of course, the developed length and the required cross-section. These approximations may be stated as follows:

1. The required length of the magnet for a given application is approximately inversely proportional to the coercive force of the material (H_c). See the Table.
2. The required cross-section varies approximately inversely with the residual induction (B). See the Table.

In arriving at these approximations, the leakage flux of the magnet is either neglected or is assumed to be equivalent for magnet designs for the various alloys considered.[1]

From a consideration of the Table, it is evident that the newer alloys are characterized by higher values of coercive force (H_c) and, in general, by lower values of residual induction (B), than Alloys



The larger induction furnace units for producing Alnico.

No. 1 and 2. Equivalent designs of magnets, to replace magnets designed for Alloys No. 1 and 2, should be correspondingly shorter in developed length and larger in cross-sectional area.

Magnet for Electrical Measuring Instruments

As previously mentioned, the requirements of permanent magnets for electrical measuring instruments are exacting.[3] These may be listed briefly as follows:

1. The magnets must be compact and of minimum weight. This requires efficient use of the material.
2. The magnets must be of uniform quality, both mechanically and magnetically. This requires well-developed and controlled processes of production.
3. They must have a high degree of magnetic stability as a function of time and conditions of service.
4. The designs must be such as to allow economical production in quantity.

The accomplishment of these objectives, utilizing the improved alloys to replace the older ones, can best be illustrated by actual examples. Fig. 2 illustrates actual designs as previously made from chromium steel and as re-designed for "Alnico."

It will be noted that cold-rolled steel has been used to complete the magnetic circuit in all of these designs. This is necessary because of the short length of the Alnico required and the necessity of maintaining interchangeable air-gap dimensions with the older designs. Cold-rolled steel contributes practically no benefit as a permanent magnet material but is a good conductor of the flux supplied by the Alnico. The marked change in the dimensions and the radical change in design required is readily evident.

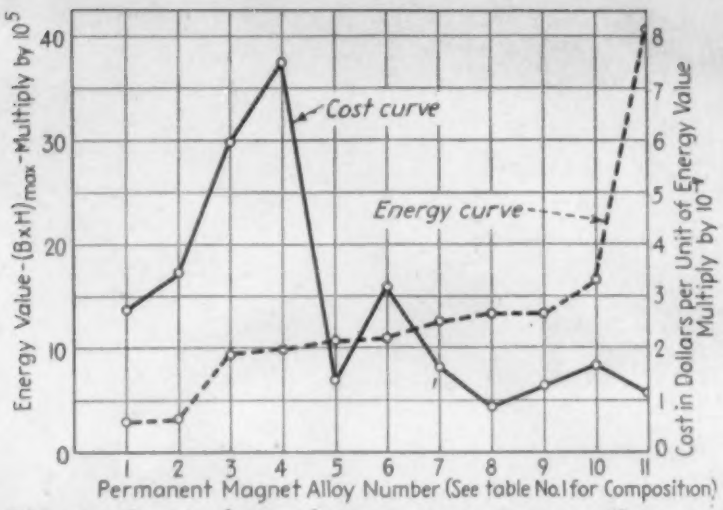

Energy Value - $(B \times H)_{max}$ - Multiply by 10^5
Cost in Dollars per Unit of Energy Value Multiply by 10^{-4}
Cost curve
Energy curve
Permanent Magnet Alloy Number (See table No.1 for Composition)

Fig. 1. Comparison of permanent magnet alloys on the basis of energy value and cost per unit of energy value.

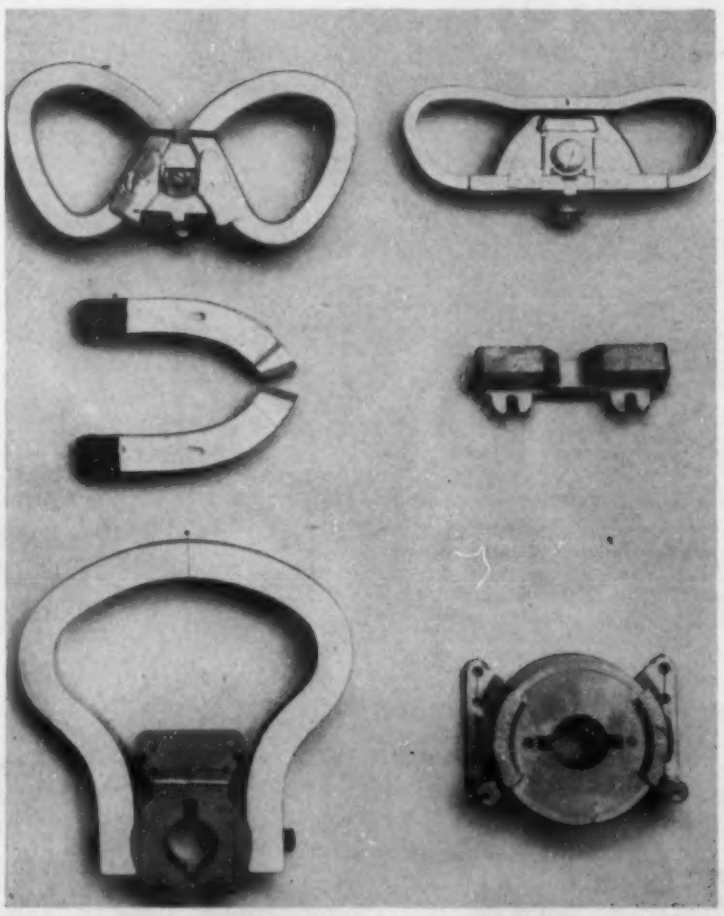


Fig. 2. Actual designs as previously made from chromium steel and as re-designed for Alnico.

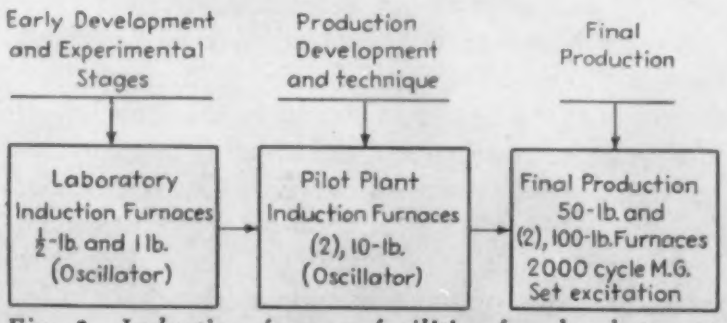

Early Development and Experimental Stages
Production Development and technique
Final Production
Laboratory Induction Furnaces ½-lb. and 1 lb. (Oscillator)
Pilot Plant Induction Furnaces (2), 10-lb. (Oscillator)
Final Production 50-lb. and (2), 100-lb. Furnaces 2000 cycle M.G. Set excitation

Fig. 3. Induction furnace facilities for development and production of magnets.

Production Methods and Equipment

The commonly employed methods of manufacturing magnets from chromium steel or tungsten steel will be described before dealing with the methods required for Alnico. Alnico represents the most widely-used group of the new alloys, and its manufacture will be treated to the exclusion of the other alloys.

The chromium or tungsten steel is purchased in rolled or drawn bar or rod of the desired cross-section. This stock is cut into lengths and heated to the forming temperature. While at temperature, it is shaped around a suitable form by means of a fixture or press. After forming, the magnets are allowed to cool, and any drilling or machining required is performed. They are then heated to the hardening temperature and quenched. Final critical dimensions are obtained by grinding.

These methods cannot be used to fabricate magnets from Alnico. The Alnicos are a hard, brittle group of alloys which can be produced in only two ways:

1. Sintered process
2. Casting and grinding

The sintering process is ideal for small magnets of certain designs but has definite limitations above a certain size. The process consists of blending the alloying elements in powder form by milling, pressing the powder mixture into a mold under high pressure, and firing the pressed parts usually in hydrogen for a length of time at a high temperature until diffusion of the components produces a homogeneous alloy. The magnetic properties of properly made sintered material are equivalent to cast material of the same composition.

One advantage of the process is that the pressed parts, before firing, are strong enough to allow drilling and machining operations to be performed before final firing. Reasonably good dimensions can be held, and for small high production parts, this process has real advantages. The bulk of Alnico magnets produced, however, are made by casting and grinding.[3]

The magnet must, of course, be designed for casting and either a baked sand, green sand, or a permanent mold in some cases, may be employed. The material cannot be readily machined or drilled even with Carboloy tools, and such operations should be avoided in the design. Inserts of material, such as cold-rolled steel, may be cast in and drilled or machined out afterwards, and this is commonly done.

The casting technique is very important and must be well worked out, as the magnet goes practically from the molten state to its final form in a few seconds. Not only must a good casting be obtained mechanically, but the magnetic properties as well must be considered. For the majority of castings,

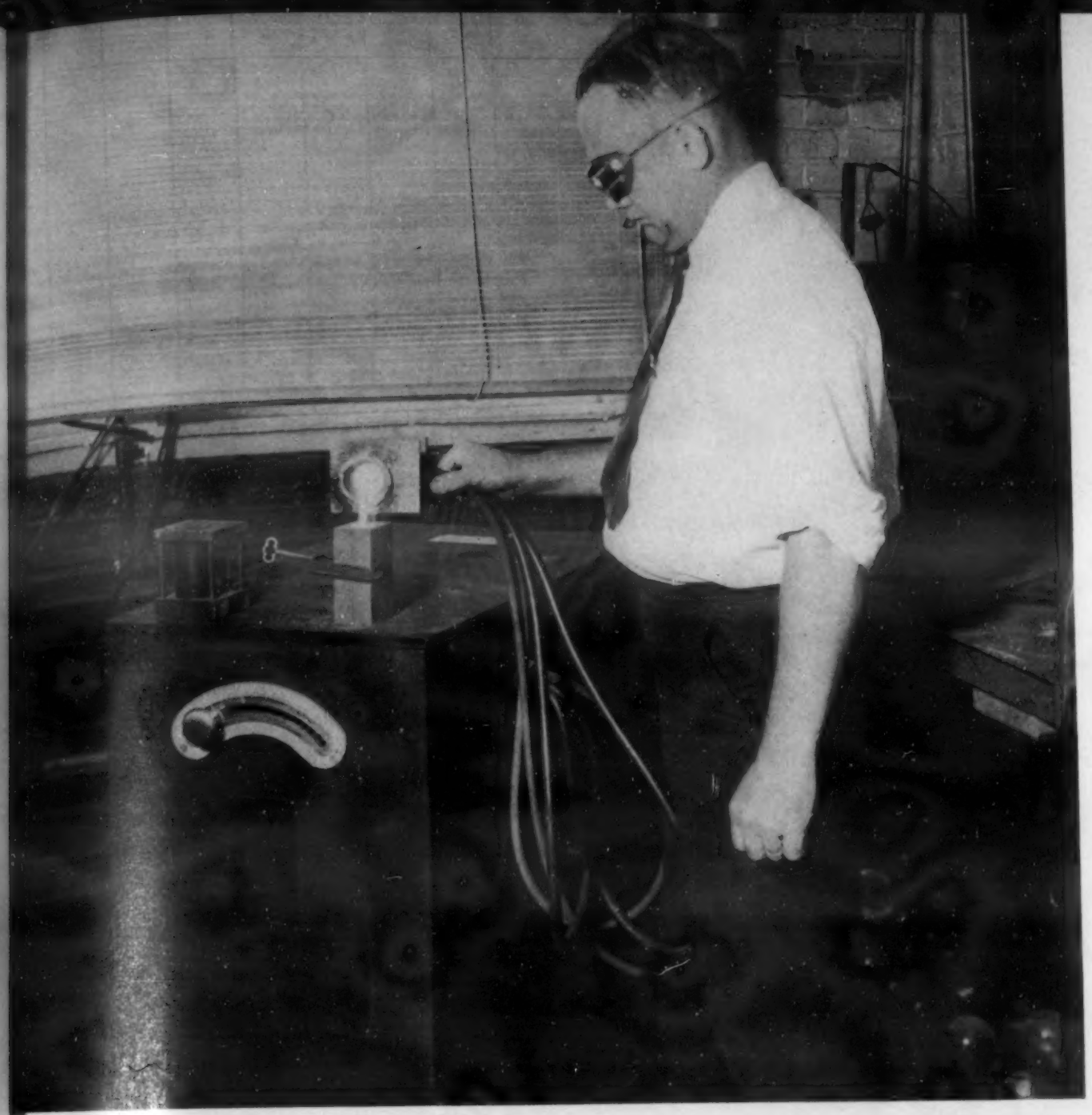


Fig. 4. One of the induction furnace installations.

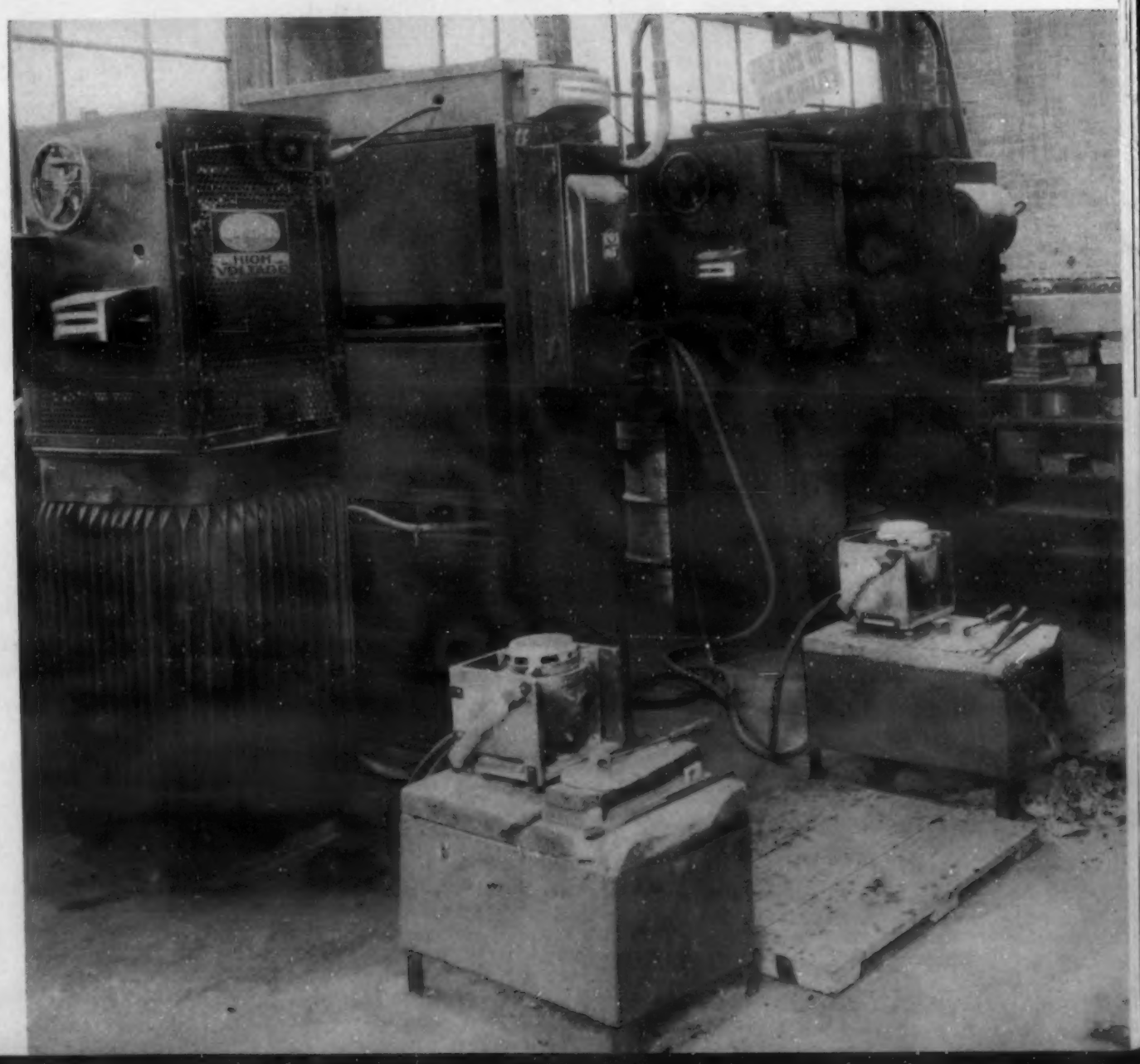
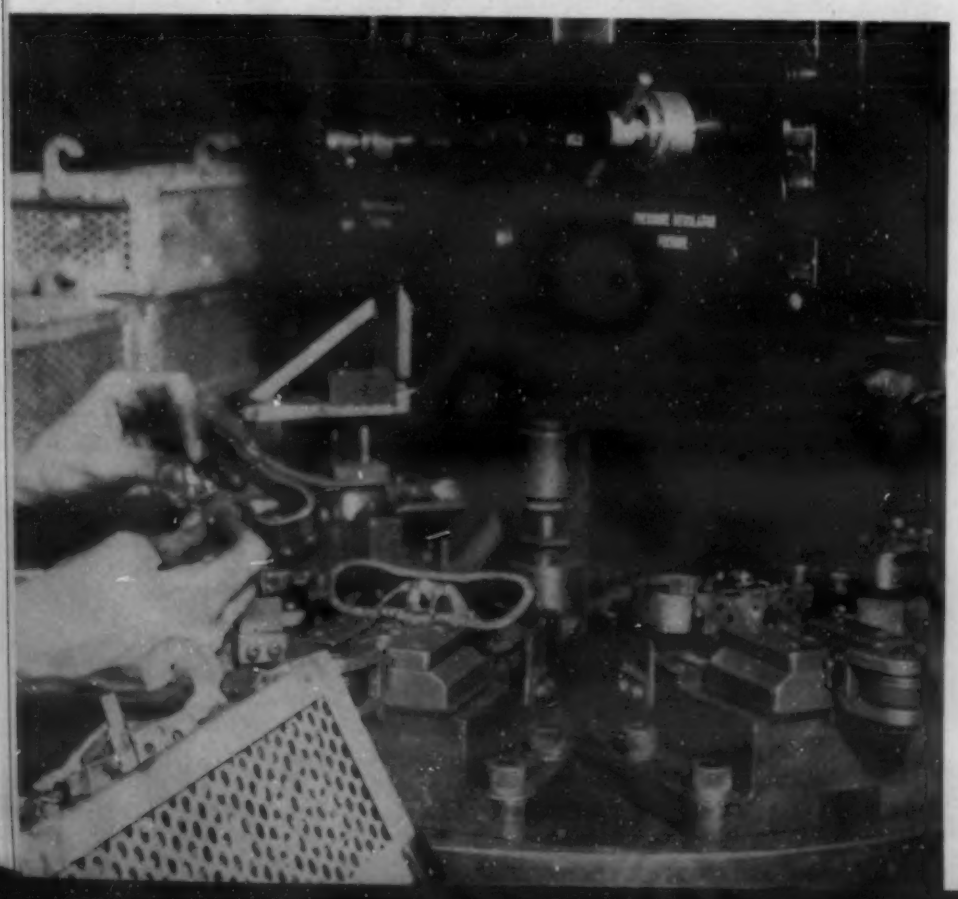


Fig. 5. Another one of the induction furnace installations.

Fig. 6. Detail of one of the magnets produced in large quantities.

Fig. 7. One of the steps in the production of permanent magnets—pyrometric check of alloy temperature.

Fig. 8. Welding the yoke to the magnet base in the production of Alnico.



optimum magnetic properties are obtained by heat treatments subsequent to casting.

Influence of Casting Technique

The casting technique has a pronounced influence on the production of the magnet for three reasons:

1. The magnetic quality is dependent upon the casting process.
2. Uniformity of quality must be obtained and contamination of the melt kept to a minimum.
3. The materials are expensive and waste and contamination must be kept to a minimum.

The selection of the proper furnace and control equipment is very important. The induction furnace has been found to be ideal for handling Alnico. The metal must be kept clean and is easily contaminated by carbon and silicon pickup. The pouring temperature is between 1450 and 1700 deg. C. It is necessary to bring the melt to the temperature for pouring quickly to avoid excessive loss of aluminum and to follow a definite schedule of melting down the various ingredients such as scrap Alnico, new metal, and the addition of the aluminum just prior to pouring. The melting and pouring technique play an important part in the quality and uniformity of the magnets produced. In all of these considerations, the induction type furnace lends itself to the working out of a good manufacturing process.

Just how well the induction furnace can be adapted to the development and production of magnets from special alloys such as Alnico can be illustrated by Fig. 3. This shows the induction furnace equipment available in the West Lynn Works of the General Electric Co. It affords a logical solution to getting a new alloy into production or a new magnet design into production with a minimum of delay. The technique developed in the laboratory or test tube stage can be tried out and improved in the pilot plant or small production stage and carried forward with perhaps but minor modification to the final production stage involving the 50-lb. and 100-lb. furnaces.

This equipment has proved itself to be invaluable in cutting down the development time by following this logical progression. Actual photographs of these furnace installations are shown.

The Alnico Watthour Meter Magnet

It will be of interest to consider in more detail the design and production of one specific magnet. The damping magnets used for watthour meters represent the largest application for permanent magnets in the field of electrical measuring instruments. The magnet shown in detail in Fig. 6 is produced in such quantity that several hundred thousand pounds of Alnico II is required per year.

It will be noted from Fig. 6 that this magnet is

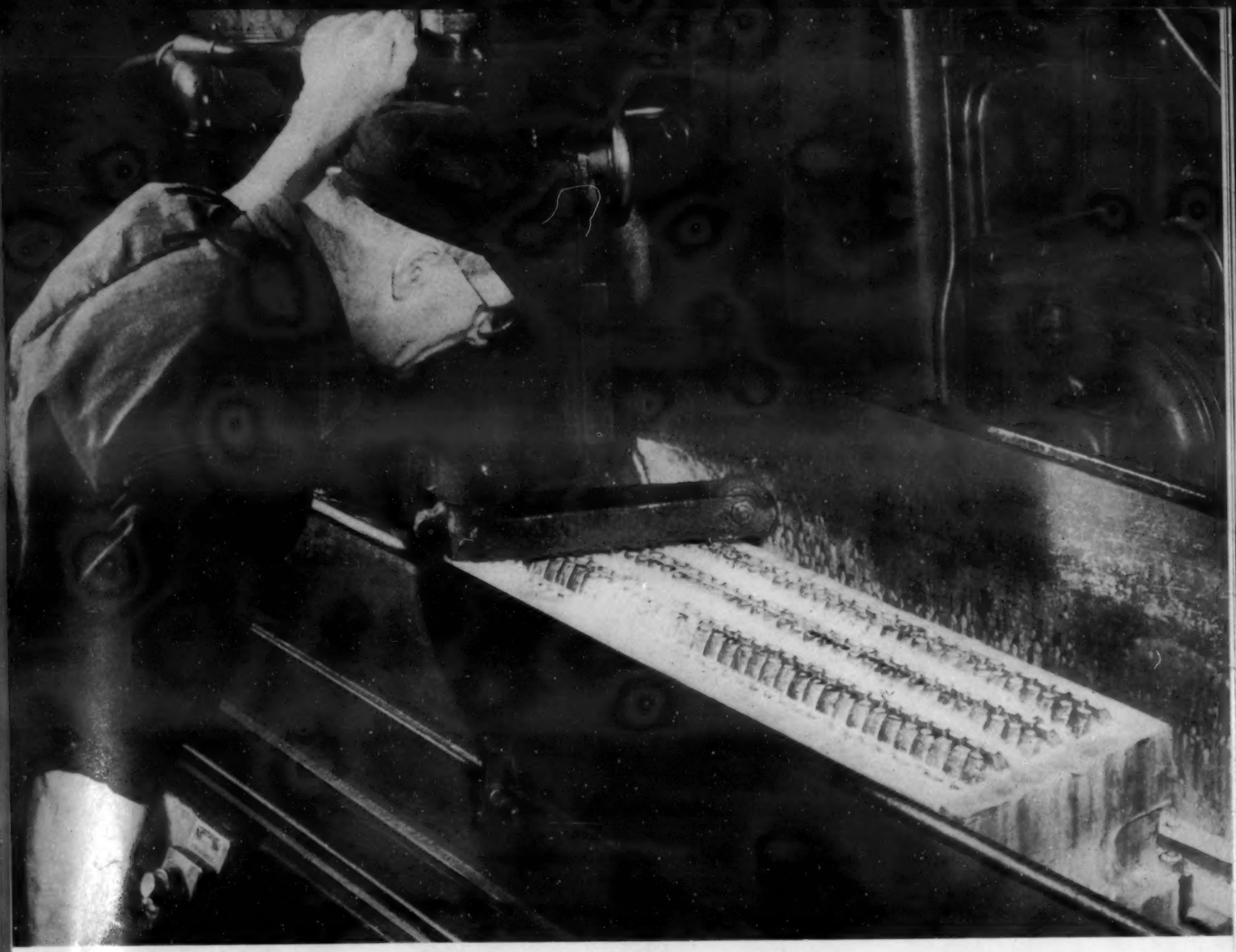


Fig. 9. Precision grinding of the magnets.

Table of Properties of Commercial Permanent Magnet Alloys

Alloy	Typical Composition Per Cent	Coercive force (H)	Residual indn. (B)	B × H max.	Mechanical properties	Commercial methods of fabrication
1. Chromium magnet steel	3.5 Cr, 1 C bal. Fe	63	9,000	295,000	Hard and strong	Hot forge, punch and machine
2. Tungsten magnet steel	5 W, 1 C, bal. Fe.	70	10,300	320,000	Hard and strong	Hot forge, punch cast, machine
3. Cobalt (36%) magnet steel	36 Co, 3.5 Cr, 1 C, bal. Fe	210	9,000	930,000	Hard and strong	Hot forge, punch cast, machine
4. Cobalt-nickel copper alloy	41 Co. 24 Ni, 35 Cu	440	5,300	993,000	Ductile	Cold-roll, machine, punch cast
5. Iron-nickel copper alloy	20 Fe, 20 Ni, 60 Cu	450	5,300	1,070,000	Ductile	Cold-roll, machine, punch
6. Comol magnet alloy	12 Co, 17 Mo, bal Fe	245	10,300	1,100,000	Hard and strong	Hot-forge, punch machine, cast
7. Alnico IV	12 Al, 28 Ni, 5 Co, bal. Fe	700	5,200	1,250,000	Hard and brittle	Cast, sinter, or grind
8. Alnico III	12 Al, 25 Ni, bal. Fe	400	7,100	1,330,000	Hard and brittle	Cast, sinter, or grind
9. Alnico I	12 Al, 20 Ni, 5 Co, bal. Fe	400	7,100	1,330,000	Hard and brittle	Cast, sinter, or grind
10. Alnico II	10 Al, 17 Ni, 12.5 Co, 6 Cu	540	7,200	1,650,000	Hard and brittle	Cast, sinter, or grind
11. Alnico V	8 Al, 14 Ni, 24 Co, 3 Cu, bal. Fe	525	12,000	4,000,000	Hard and brittle	Cast, grind

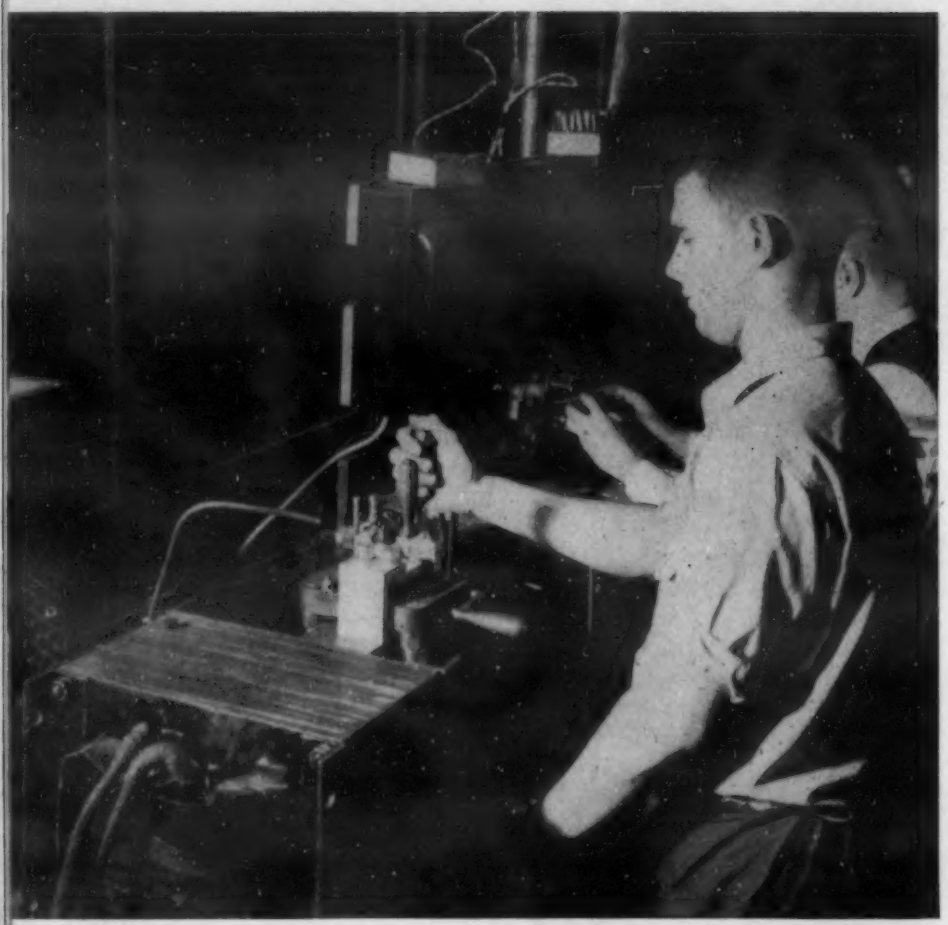


Fig. 10. Magnetizing the magnet.

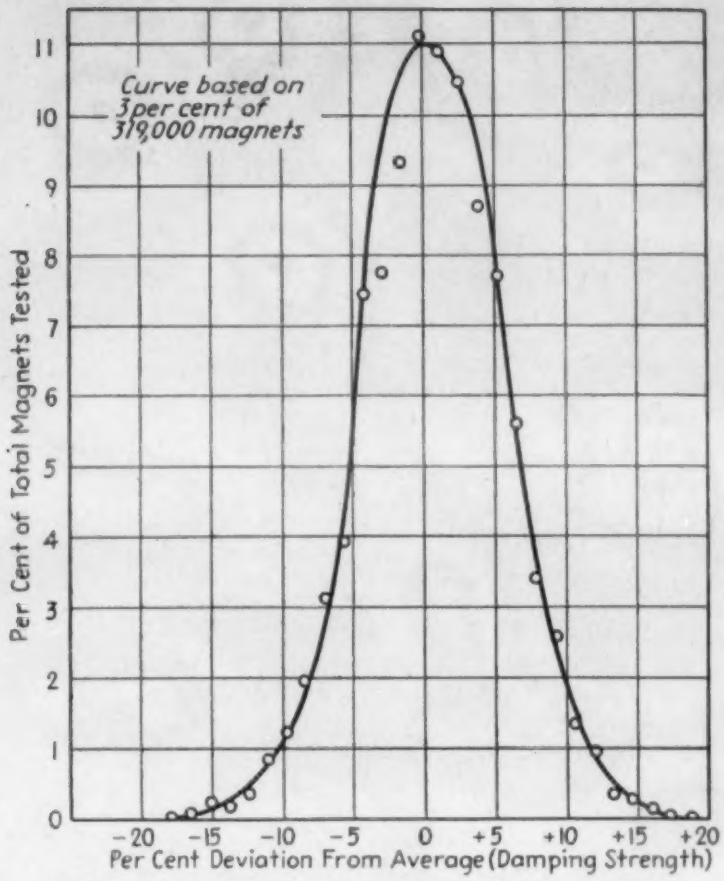


Fig. 11. Magnet strength distribution curve.

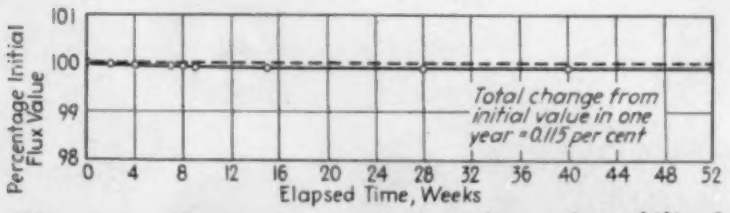


Fig. 12. Room temperature aging of stabilized Alnico watthour meter damping magnets.

made up of an assembly of two cast poles which are of Alnico II together with a cold-rolled steel base and top yoke. These parts represent the magnetic circuit. The poles are cast integral with the base plate, the Alnico poles being fastened directly to extended anchorages drawn out of the base plate. The base plate and pole unit is resistance welded to the top yoke forming a rigid one piece assembly. The other parts of the assembly are to provide adjustment of the magnet. Steps in the manufacturing process are shown in Figs. 7, 8, 9 and 10.

In order to give some idea of the uniformity of magnetic quality obtained, Fig. 11 has been included. This figure represents the magnetic strength of 319,000 magnets produced over a given period from samples selected at random. These data are measured magnetic strength in terms of the damping force produced by the magnet on the driving disc of a given watthour meter. The damping force is proportional to the square of the magnet flux. The variation of ± 10 per cent in damping strength from the mean value actually means a change in flux of only ± 5 per cent. This is excellent control of magnetic quality as it also takes into account variations in the dimensions of the air gap which are quite important.

The permanency of this magnet, with respect to time, is also very important.[4] This is in a large measure tied up in the casting process, but special aging or stabilizing treatments are given subsequently to the finished magnet. Fig. 12 represents the stability obtained by the complete process.

This change in strength with time is negligible and can only be detected by very accurate measurements. This one example clearly shows what can be accomplished with proper utilization of the new materials if proper design and equipment are employed.

References

[1] "Permanent Magnets in Theory and Practice," S. Evershed, *J. Inst. Elec. Engrs.*, Vol. 58, Sept. 1920, pages 780-837.

[2] "Braking Magnets for Watt-Hour Meters," I. F. Kinnard and J. H. Goss, Suppl. to *Elec. Eng. Trans. Sec. Amer. Inst. Elec. Engrs.*, June 1941, pages 431-439.

[3] "Alnico—Its Properties and Possibilities," J. Q. Adams, *Gen. Elec. Rev.*, Vol. 41, Dec. 1938, pages 518-522.

[4] "Development of a Modern Watthour Meter," I. F. Kinnard and H E. Trekell, *Elec. Eng.*, Jan. 1937, pages 172-179.

Reference Table of

CASTING PROPERTIES OF FOUNDRY PRODUCTS

Ferrous and Non-Ferrous

Compiled by H. R. Clauser

Metal or Alloy	*Nominal Composition, Per Cent*	*Solidification Range Deg. F.*	*Shrinkage in. per ft.*	*Specific Gravity*	*Wt. in lbs. per cu. in.*
Aluminum	99+ Al	1215 M. P.	5/32+	2.70	0.098
Aluminum-copper alloy	92 Al; 8 Cu	1165-975	5/32	2.83	0.102
Aluminum-copper-silicon alloy	4 Cu; 3 Si; 93 Al	1170-970	5/32	2.75	0.099
Aluminum-magnesium alloy	4.0 Mg; 96.0 Al	1185-1075	5/32	2.63	0.095
Aluminum-manganese alloy	2.0 Mn; 98.0 Al	1255-1215	5/32	2.73	0.099
Aluimnum-silicon alloy	12.0 Si; 88.0 Al	1150-1070	5/32	2.65	0.096
Aluminum-zinc alloy	2.5 Cu; 1.3 Fe; 11.0 Zn; 85.2 Al	1165-980	5/32	2.94	0.106
Copper	99+ Cu	1980 M. P.	3/16	8.80	0.317
Copper-nickel alloy	45 Ni; 55 Cu	2325-2235	1/4	8.60	0.310
Cupro-nickel	30 Ni; 70 Cu	2250-2140	3/16	8.80	0.317
Bell metal	20 Sn; 80 Cu	1600-1450	3/16	8.70	0.313
Nickel brass (Nickel silver)	20 Ni; 15 Zn; 65 Cu	2060 approx.	3/16	8.50	0.316
Red brass	5 Zn; 5 Pb; 5 Sn; 85 Cu	1775 approx.	3/16	8.75	0.314
Medium red brass	77Cu; 10 Zn; 10 Pb; 3 Sn	1775 approx.	3/16	8.68	0.312
Gunmetal	8 Sn; 4 Zn; 88 Cu	1825-1775	1/8	8.30-8.60	0.300-0.310
Aluminum-bronze	10 Al; 90 Cu	1920 approx.	7/32	7.50	0.271
Manganese-bronze	55-60 Cu; 38-42 Zn; 3.5 max. Mn	1675 approx.	7/32	8.40	0.303
Leaded bearing bronze	80 Cu; 10 Pb; 10 Sn	1725 approx.	3/16	8.90	0.324
Silicon bronze	94 Cu; 5 Si; 1 Mn	1830 approx.	3/16	8.20	0.297
Magnesium-base alloy	3.5-10 Al; 3.5 max. Zn; remainder Al	1150 approx.	5/32-1/8	1.83 max.	0.066
Lead-base bearing alloy	75 Pb; 15 Sb; 10 Sn; 0.50 max. Cu; 0.20 As	515-465	———	9.73	0.350
Lead-antimony alloys	90 Pb; 10 Sb	500-475	———	10.67	0.386
Lead-tin-antimony alloys	80 Pb; 5 Sn; 15 Sb	500-460	———	10.04	0.363
Babbitt	90 Sn; 5 Cu; 5 Sb	690-430	———	7.34	0.265
High nickel-copper alloy	70 Ni; 30 Cu	2500-2400	1/4	8.80	0.317
High nickel-copper-silicon alloy	65 Ni; 30 Cu; 3-5 Si	2400-2300	1/4	8.65	0.312
Zinc-base alloy (die casting)	0.10 max. Cu; 3.5-4.3 Al; remainder Zn	720 approx.	5/32	6.60-6.70	0.238-0.242
Gray iron		2400-2000	1/8	7.00-7.50	0.252-0.271
White iron		2100-2065	3/16-1/4	7.70	0.277
Malleable iron		2100-2065	3/16	7.20-7.45	0.259-0.268
Low carbon cast steel	Less than 0.20 C; 0.50-1.00 Mn; 0.20-0.75 Si; 0.05 P max.; 0.06 S max.	2730-2615	1/8-1/4	7.86	0.284
Regular carbon cast steel	0.20-0.40 C; 0.50-1.00 Mn; 0.20-0.75 Si; 0.05 P max.; 0.06 S max.	2695-2590	1/8-1/4	7.86	0.284
High carbon cast steel	More than 0.40 C; 0.50-100 Mn; 0.20-0.75 Si; 0.05 P max.; 0.06 S max.	2670-2160	1/8-1/4	7.80-7.86	0.282-0.284
Alloy cast steel		2730-2280	up to 5/8	7.50-8.10	0.271-0.293

TIN CONSERVATION

Silver in Lead-Base Babbitts

by H. W. GILLETT and R. W. DAYTON

Battelle Memorial Institute, Columbus, Ohio

The increasingly critical tin situation impels the development and the widest possible use of satisfactory low-tin or no-tin alternates for bearing metals, solders, coatings, bronzes, etc. that ordinarily consume large amounts of that metal. This article is a preliminary report on the properties, as compared to tin-base babbitts and silver-free lead-base babbitts, of new and extremely promising lead-base babbitts containing silver, developed specifically to provide a replacement material that would closely approach the hard-to-beat tin-base babbitts in essential bearing properties.

For an analogous tin-saving development in the field of solders, readers are referred to the report of Turkus & Smith on new low-tin solders containing silver and bismuth, published in our March issue. Other tin-conservation articles have been published also in the January 1942 (pages 67-80), November, 1941 (page 704), November 1940 (page 641) and the September, October, November and December, 1940 ("Bearing Metals and Strategic Materials") issues. —*The Editors.*

A SHORTAGE OF TIN makes it necessary to consider possibilities in the replacement of tin-base babbitts. These alloys have such a well-rounded set of properties that, in spite of the economic urge that has always existed to replace them with cheaper materials, no substitutes with all of their desirable characteristics have been found.

The evaluation of the "bearing properties" of a "bearing metal" is difficult. Merely to enumerate, to say nothing of quantitatively measuring, all the properties that make tin-base babbitt useful is quite a task, and determining the proper balance of these properties necessary in an acceptable substitute is a still greater one. Most of these properties, in approximately the same balance, are found in lead-base babbitts. In service, however, the lead-base babbitts are not considered to be quite as good unless they are used as an extremely thin layer. When used in a thin enough layer, supported by a stronger backing, recent automotive practice has proven lead-base babbitt to be the equivalent of a thicker layer of tin-base babbitt.

Shortage of tin thus brings no difficulties in those uses where snap-in, backed bearings are applicable. But there are many bearings in which the alignment is not precise enough to allow the use of such thin linings, and many old, thick bearings are in service that have to be relined, from time to time, with a thick babbitt lining.

Essential Bearing Properties

The properties which led to the selection of tin-base babbitt for these thick linings instead of the cheaper lead-base, appear to be primarily (1) ease of bonding, and (2) resistance to squeezing out at operating temperature. Many of the substitute materials suggested to provide the same hot strength as tin-base babbitt are decidedly harder at room temperature and may thus be inferior in their embeddability for grit.

An intelligent way of providing a true equivalent for tin-base babbitt appears to be to equal, *but not greatly to exceed,* its mechanical properties. A babbitt with the same hardness-temperature curve[1] as that of tin-base babbitt, and one that retains its hardness after long ageing at operating temperature, as tin-base babbitt does, might therefore be the objective as has been previously stated.[2]

Beside this kind of equivalence, equivalence in bondability and in corrosion resistance is also to be sought.

The ordinary lead-base babbitts come closest to

tin-base babbitts in most properties, but they lack elevated temperature hardness and bondability.

The addition of a little silver to lead markedly improves its retention of hardness at elevated temperature, and also changes lead from a very poorly bonding material to a solder of recognized value. It, therefore, seemed logical to expect that silver added to ordinary lead-base babbitt might make it much more nearly the equivalent of tin-base babbitt.

Since the most obvious deficiencies of lead-base babbitts were hot hardness and bondability, tests of these properties were used for the preliminary weeding out of the experimental alloys. As the work progressed and useful alloys were developed, these tests were supplemented by simulated-service tests of full-size bearings, deformation tests, and corrosion tests.

The work can be divided into two parts, first, the selection of the best composition of a lead-base babbitt containing the usual elements; and second, the effect of hitherto unused elements for obtaining further improvement. In the first part, it was found that the amount of tin in the alloys was critical, since the alloys were weak if either too much or too little were present, and that copper was a desirable addition, improving both hardness and bondability. In the second part, it was found that silver was an excellent addition, improving the hot hardness but not causing a corresponding increase in cold hardness and not at the expense of an increase in brittleness. Bondability was decidedly improved.

The alloys tested were melted in a clay-graphite crucible under a cover of fine charcoal, and poured into a 1.2 centimeter (0.473 in.) diameter, 7 centimeter (2.75 in.) long steel mold. The mold was heated to 200 deg. F. prior to casting. The alloys all were made of rather pure materials, so the amount of impurities was small.

Comparative Data

Alloys were made containing various amounts of antimony, tin and copper, and various additions including cadmium, arsenic, tellurium and silver until the optimum range of composition for the new alloys was determined. It was found that aside from those elements commonly used as hardeners, only silver was a really successful addition in all respects. The results of this part of the study are summarized in Table 1, in which are given data for the best of the many alloys tested.

The data in this table include hardness, bondability and ductility. The hardness was measured in Brinell figures, the impressions were made and measured on a Vickers hardness tester using a 2.5-mm. ball and loads from 2 to 5 kgs., depending on the hardness. Hot hardness tests were made by supporting the specimens in a hole in a heated aluminum cylinder. Hot hardness impressions were made with the load applied both for 30 and for 300 secs., to obtain some idea of the flow characteristics of the materials.

The data on bondability were obtained on 2-in. square sheets of steel that had been pickled and fluxed. Small samples of the alloy to be tested for bondability were placed on top of the steel plates and the plates heated from below with a torch until the babbitt stopped flowing. Babbitts that flowed readily were classed as good; those which did not, as poor. Perhaps this test should be called a "flowability" test, but since the ease with which the alloys wet steel is a factor, the test comes as close as any known to measuring the property desired—ease of bonding. It is realized, however, that such flowability tests are far from perfect. For instance, with extremely perfect cleaning, it has been found that

Table I—Comparative Properties of Tin-Base, Lead-Base and Lead-Silver-Base Babbitts

Alloy Type	Designation: Alloy No.	Designation: Spec'n.	Composition, per cent: Pb	Ag	Sb	Sn	Cu	Brinell Hardness[1]: As Cast[2]	Aged[3]	Age and Test—300 deg. F.: 30 Sec.	300 Sec.	Ease of bonding	Ductility,[4] per cent
Tin-Base	398	ASTM No. 2	—	—	7.5	bal.	3.5	19	17	6.0	4.4	—	99
	399	ASTM No. 3	—	—	8.3	bal.	8.3	20	20	7.2	5.5	—	91
Lead-Base	401	SAE No. 13	bal.	—	10	5	—	21	17	6.4	4.0	—	—
	403	SAE No. 14	bal.	—	15	10	—	26	18	6.5	4.2	—	53
	402	ASTM No. 8	bal.	—	15	5	—	22	17	5.8	3.7	—	—
	400	ASTM No. 10	bal.	—	15	2	—	21	16	6.4	5.0	poor	50
	407	ASTM No. 10	bal.	—	15	2	0.2	18	18	7.1	5.4	fair	40
Lead-Silver-Base	366	— —	bal.	5.1	15	—	0.2	22	16	6.0	3.8	—	—
	367	— —	bal.	5.0	15	2	0.2	23	21	8.9	6.6	good	40
	368	— —	bal.	4.8	15	5	0.2	25	19	7.2	5.9	—	57
	394	— —	bal.	4.8	15	5	—	22	18	6.9	4.7	—	77
	397	— —	bal.	2.6	10	3	—	21	18	7.2	5.2	good	59

[1] 2.5 mm. ball, loads of 2 to 5 kgs. Load applied for 11 secs. except where otherwise specified.
[2] Hardness measured after 24 hrs. at room temperature.
[3] Aged for 24 hrs. at 300 deg. F.
[4] The ductility was measured by pounding down a specimen of standard size until cracking had occurred. The percentage reduction in thickness to cause this cracking is the figure given.

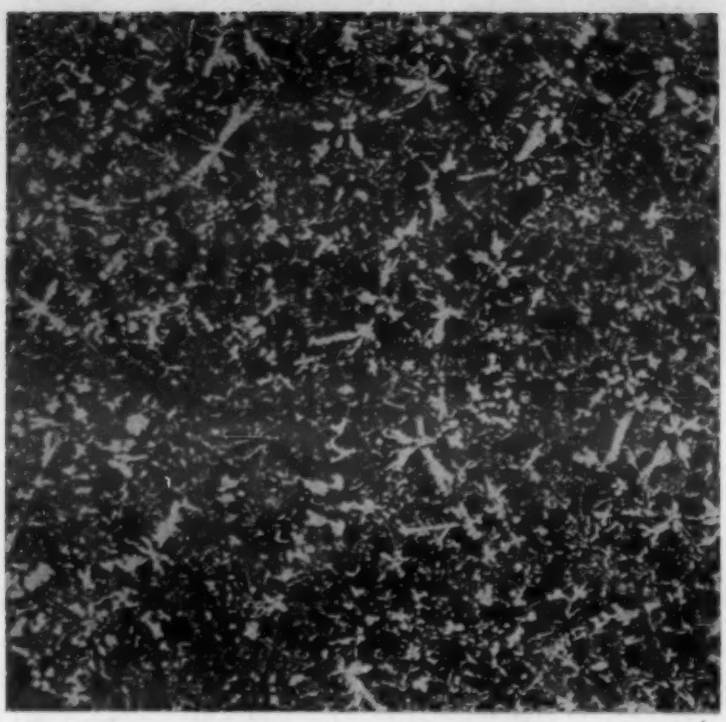


Fig. 1. Structure of alloy No. 397 which contains 10 Sb, 3 Sn and 2.6 per cent Ag, balance Pb. 150X.

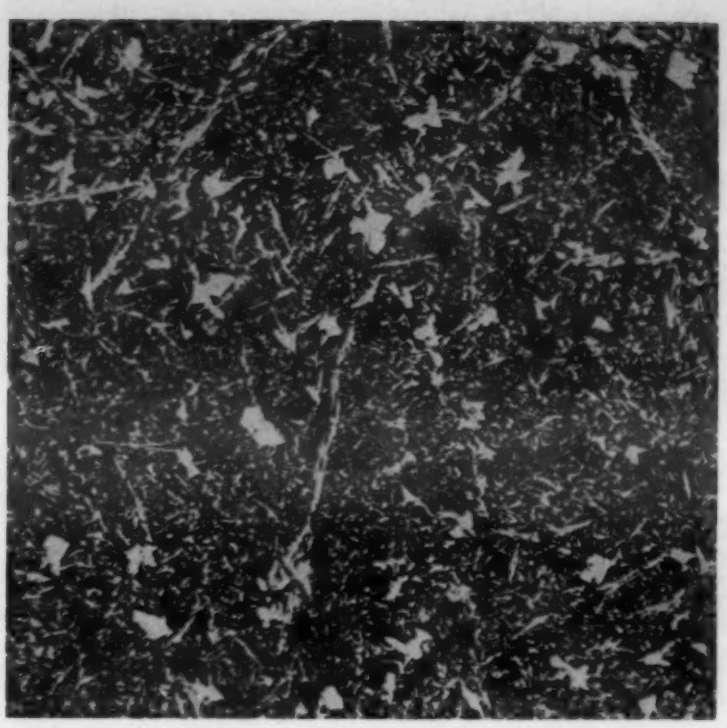


Fig. 2. Structure of alloy No. 367 which contains 15 Sb, 2 Sn, 0.2 Cu, 5 per cent Ag, balance Pb. 150X.

Table II. Results of Underwood Corrosion Tests

Designation		Composition, per cent					Wt. Loss[1]—Gram	
Alloy No.	Spec'n. No.	Pb	Ag	Sb	Sn	Cu	Oil + iron naphthanate	Oil + oleic acid
398	ASTM #2	—	—	7.5	bal.	3.5	0.000	0.006
399	ASTM #3	—	—	8.3	bal.	8.3	0.000	0.002
403	SAE #14	bal.	—	15	10	—	0.000	0.002
364		"	6.0	—	—	—	0.084	0.324
367		"	5.0	15	2	0.2	0.002	0.003
397		"	2.6	10	3	—	0.003	0.014

[1] During 8-hr. test at 325 deg. F.

pure lead will spread over a steel surface even better than pure tin, though it is much more difficult to bond. When cleaning is less perfect, approaching commercial conditions, tin of course will flow better.

The ductility data were obtained by pounding down cylinders of the material under test with hammer blows of constant impact until the first signs of cracking appeared. The thickness was then measured and the reduction in height from the original thickness was a measure of ductility.

Discussion of the Alloys

The first two alloys reported in Table 1 are tin-base babbitts. Their hardness at room temperature is a little lower than values reported in the literature for the same alloys; this may be due to the conditions of melting and casting.

The next five alloys in Table 1 are lead-base babbitts, and the hardness values reported are approximately those found in the literature. Comparison of these alloys with the tin-base babbitts shows that the lead-base babbitts, though equally hard as cast, lose hardness when aged and at high temperature are not so hard as the tin-base alloys. Furthermore the lead-base alloys flow more in the hardness test under long-time loading.

To some extent, these lead-base babbitts can be improved by manipulation of their composition. Alloys with large amounts of tin like the first three lead-base alloys are particularly susceptible to loss of hardness by ageing and flow. Reducing the tin content to 2 per cent in an alloy that contains 15 per cent Sb reduces the hardness loss at high temperatures.

Additions of copper decrease the hardness loss at high temperature due to ageing and flow, simultaneously improving bondability. However, copper decreases the ductility and this is thought by some users to be undesirable.

The best of the lead-base babbitts is Alloy No. 407, conforming to the specifications for ASTM No. 10, which contains 15 Sb, 2 Sn, 0.2 per cent Cu, and the balance lead. This alloy is nearly the equivalent of tin-base babbitt except for bondability and ductility.

Additions of silver to lead-base babbitts produce further improvements beyond that obtainable from a manipulation of the basic ingredients in lead-base babbitts. The improvements are obtained in hot hardness and bondability and are obtained without sacrificing ductility. By the use of silver in lead-base babbitts, it is possible to produce alloys either of greater strength and equal ductility or of equal

strength and greater ductility, both with improved bondability.

The strongest of the alloys produced by the addition of silver is Alloy No. 367, which contains 5 per cent Ag. This alloy is 20 to 25 per cent stronger than either the strongest lead-base babbitt or the strongest tin-base babbitt. Bonding of the silver-containing alloy is far better than that of the straight lead-base alloy.

Another alloy, No. 379, is just as strong as either the best lead-base alloy or the best tin-base alloy, but it is 50 per cent more ductile than the lead-base alloy and it bonds more readily.

Some Commercial Considerations

It is evident that silver performs a highly useful function in lead-base babbitts, and that silver-lead base babbitts can be compounded that approach the properties of tin-base babbitt more closely than do alloys now in use.

The cost of the alloy, in spite of the silver, is lower than that of tin-base babbitts, and although this is not important during a tin shortage, it would be under normal conditions. The cost of the metals in tin-base babbitt, at 1941 prices, is in the range of 45-50c per lb., that of the 2.6 per cent Ag alloy is 21c per lb., and that of the 5 per cent Ag alloy is 33c per lb.

The best of the lead-silver base babbitts were chosen for further study. These two alloys were No. 367, which contained 15 Sb, 2 Sn, 0.2 Cu, 5 per cent Ag, balance lead and Alloy No. 397, which contained 10 Sb, 3 Sn, 2.06 per cent Ag, balance lead. These were compared in various tests with the best tin-base babbitts and the best lead-base babbitts.

The microstructure of the alloys was examined and it was found that the structure of the new alloys was similar to that of ordinary bearing alloys, as the photomicrographs of Figs. 1 and 2 show.

Amsler seizure tests were made, and it was found that there was practically no difference in the results for the various alloys. The two lead-silver-base alloys were found to have a seizure resistance of 3600-3900 lbs. per sq. in., the lead-base babbitts to have a seizure resistance of about 3500 lbs. per sq. in., the tin-base babbitts to have a seizure resistance of about 3000 lbs. per sq. in. The differences are quite insignificant. The new alloys are the equivalent of tin-base babbitts in seizure resistance.

Corrosion tests were made in an Underwood Oxidation Testing apparatus, following the procedures recommended by the General Motors Research Laboratories. Tests were made in two types of corrodants, oil whose oxidation was catalyzed by the addition of iron naphthenate, and oil to which 1 per cent of oleic acid has been added. The results of the corrosion tests are shown in Table 2. It is apparent that the lead-silver babbitts are satisfactorily resistant to corrosion. The results for a straight silver-lead alloy, which is not resistant to corrosion, are included in the table for comparison.

Tests of full-size connecting rod bearings, 2 in. inside diameter, 2⅜ in. outside diameter and 1.28 in. long, lined with a 0.020 in. thick layer of babbitt, were made on a General Motors type of bearing machine. The test speed was 3550 r.p.m., the bearing load 1100 lbs. per sq. in., the bearing temperature 300 deg. F. These conditions sufficed to cause fatigue failure of the bearings in a 50-hr. test.

The materials tested included a tin-base babbitt, ASTM No. 3, a lead-base babbitt, ASTM No. 10, and the two best lead-silver-base babbitts, No. 367 and No. 397. Three tests were run on each material. The results were not clear cut and no material was markedly superior to any other. However, it was found that the lead-silver babbitts were less inclined to fail because of poor bonding than ordinary lead-base babbitt, and that they failed no worse than tin-base babbitts. In this test too, it appears that the new alloys are the equivalent of tin-base babbitt, and somewhat more reliable than lead-base babbitt. It appears that other differences in tendency for fatigue failure of the materials are overshadowed by inherent variability in complicated tests of this nature.

Comparisons of this new silver-lead babbitt were made by a large manufacturer of electric motors. Their report shows that bonding was satisfactory and that its mechanical properties were adequate. In some tests with insufficient lubrication, the tin-base babbitt ran slightly longer without failure than the silver-lead-base babbitt. The conclusions reached by the manufacturer after these tests were that the silver-lead-base babbitt was usable in the event of a shortage of tin.

These, too, are our conclusions. While the new babbitt may not be the equal of a tin-base babbitt in all respects, it is the equivalent in the more important bearing properties, and in a summation of properties approaches those of tin-base babbitt more closely than other substitutes whose properties are on record. It is believed that in the present shortage of tin, this babbitt should find considerable use.

The assistance of Dr. A. U. Seybolt and L. E. Balch in the experimental work is acknowledged with thanks.

References

[1] Compare Fig. 19, page 637—METALS AND ALLOYS, Nov., 1940.
[2] Discussion, p. 894, *Proc.* A.S.T.M., Vol. 41, 1941.

Fig. 1. A test piece, 12 in. by 2 in. by 1¼ in. of copper-bearing steel plate (0.26% Cu) soaked at 2,000 deg. F. for 4 hrs., one end flattened to approximately one-half of its original thickness and the test piece then bent back on itself. Note ruptures in compressed leg and wrinkles in bend surface.

Copper-Bearing Steel for

by F. EBERLE

Babcock & Wilcox Co., Barberton, Ohio

The fabricators of pressure vessels, tank cars, oil-refinery equipment, heavy metal containers, etc. make considerable use of copper-bearing steel for reasons of corrosion resistance or structural strength. Where the fabrication is at all massive, there is the ever-present danger that such operations as forging, hot-rolling, hot-forming and welding will result in a de-nuding of the copper through preferential oxidation of the iron at the surface, with consequent cracking because of the low melting point of this elemental copper. The danger is aggravated by the relatively high "residual" copper present in much open hearth steel, introduced therein from the scrap used in its manufacture.

Mr. Eberle finds the higher copper contents (0.25-0.30 per cent) definitely bad from the standpoint of surface cracking, but indicates several measures (notably the inclusion of enough nickel in the steel) that may aid in avoiding this trouble.—The Editors.

COPPER AND NICKEL are less readily oxidized than iron. No copper or nickel is lost in the remelting of steel scrap. Studies[1] of residual metals in steel show that for a long period of years the average composition in the carbon steels made in the United States has included about 0.10 per cent Cu and 0.05 per cent Ni. The averages for individual steel plants may run up to 0.25 per cent Cu, 0.10 per cent Ni, and individual heats may considerably exceed those figures. This is a consequence of the composition of the scrap available to these individual plants. In part, the copper content harks back to the previous production of copper-bearing steels for corrosion resistance, that have finally come back as scrap, and in part to the copper content of certain iron ores.

A result of the less ready oxidation of copper and nickel as compared with iron is that, in a prolonged heating at rolling or forging temperatures in an atmosphere oxidizing to steel (as in a soaking pit or a billet heating furnace) so that the steel scales, the scale consists of iron oxide, with a film of metallic copper or nickel, or copper-nickel alloy left between the unoxidized steel surface and the layer of scale.

tee or Heavy Fabrication—I

—Avoiding Surface Cracking

Alloys of copper and nickel have intermediate melting points, for example, one of 60 Cu-40 Ni melts around 2200 deg. F. Copper melts at about 1980 deg. F., nickel at about 2645 deg. F. Hence, at heating temperatures of 2000 deg. F., for forging or rolling, a copper film is molten, a nickel film is not, and a copper-nickel film may be liquid or solid depending on the Cu:Ni ratio.

If the film is liquid, it penetrates into intercrystalline boundaries, in a fashion similar to that encountered when a steel stirring rod is used in a melt of manganese bronze. The manganese bronze penetrates between the crystals and the rod becomes brittle.

The effect of a copper film depends on its thickness, that is, upon the amount of copper in the steel, the reservoir which is drawn upon, and upon the amount of scaling that occurred during its formation, which latter in turn depends on the time, the temperature, and the atmosphere for heating. A molten film of infinitesimal thickness penetrates only a very shallow layer of steel. A solid film does not penetrate. A thick, molten film may penetrate quite deeply to produce surface roughening, and, in severe cases, forging cracks or rolling cracks, particularly edge cracks.

Avoiding Surface Cracking

These troubles may be avoided by keeping the copper at a sufficiently low level; by adding enough nickel (if enough is not already present as residual nickel) to keep the film solid at the heating temperature; by lowering the heating temperature to such a point that the copper-nickel film, whatever its composition, remains solid; by heating in a non-scaling atmosphere; or by making the heating time so brief that despite the formation of a liquid film, the film is of negligible thickness and effect.

Obviously all these factors of amount and ratio of copper and nickel, of atmosphere and of heating time and temperature, vary. The composition as to copper and nickel varies from heat to heat of steel, depending on the nature of the scrap, and the heating conditions vary with the mass of the billet, plate, etc. that is to be hot worked, with the amount of work to be done on the piece and with the heating practice of the plant.

Taking ordinary rolling conditions, it is usually considered that no appreciably harmful effects can be noted until the copper content rises above 0.30 per cent. Several trade named steels alloyed with copper for resistance to atmospheric corrosion, or, in the mild-alloy (low alloy, high yield strength) type, for strength, are regularly produced with 0.40 per cent Cu, without the addition of nickel. However, for such steels, that scrap tends to be chosen that will give the highest residual copper, so that the minimum copper addition is required, and scrap high in residual copper tends to be high in residual nickel also, so that a suitable Cu:Ni ratio may be present, by good luck.

That surface checking may appear with as low as 0.20 per cent Cu in absence of adequate nickel, when high temperatures and long heating periods are involved, and that the cure is to drop the heating temperature or add the required nickel, has long been known, and has been fully discussed by Gregg and Daniloff.[2]

Unfortunately, heats of commercial steel appear now and then in which the residual copper is high, and to which no corrective nickel addition has been made. The plate from such a heat may behave all right in hot working if short heating times and low heating temperatures are adequate for the amount of hot working. But much of the material hot-fabricated by Babcock and Wilcox is of heavy section and demands a large degree of hot deformation.

The question was raised whether the copper content limits of the high tensile plate material for

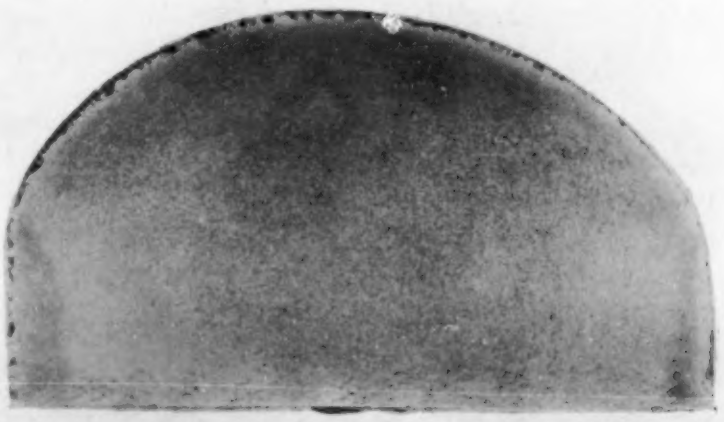


Fig. 2. Enlarged macro-etched cross section through surface of hot-bend test specimen depicted in Fig. 1. Note shallow surface tears in bent surface.

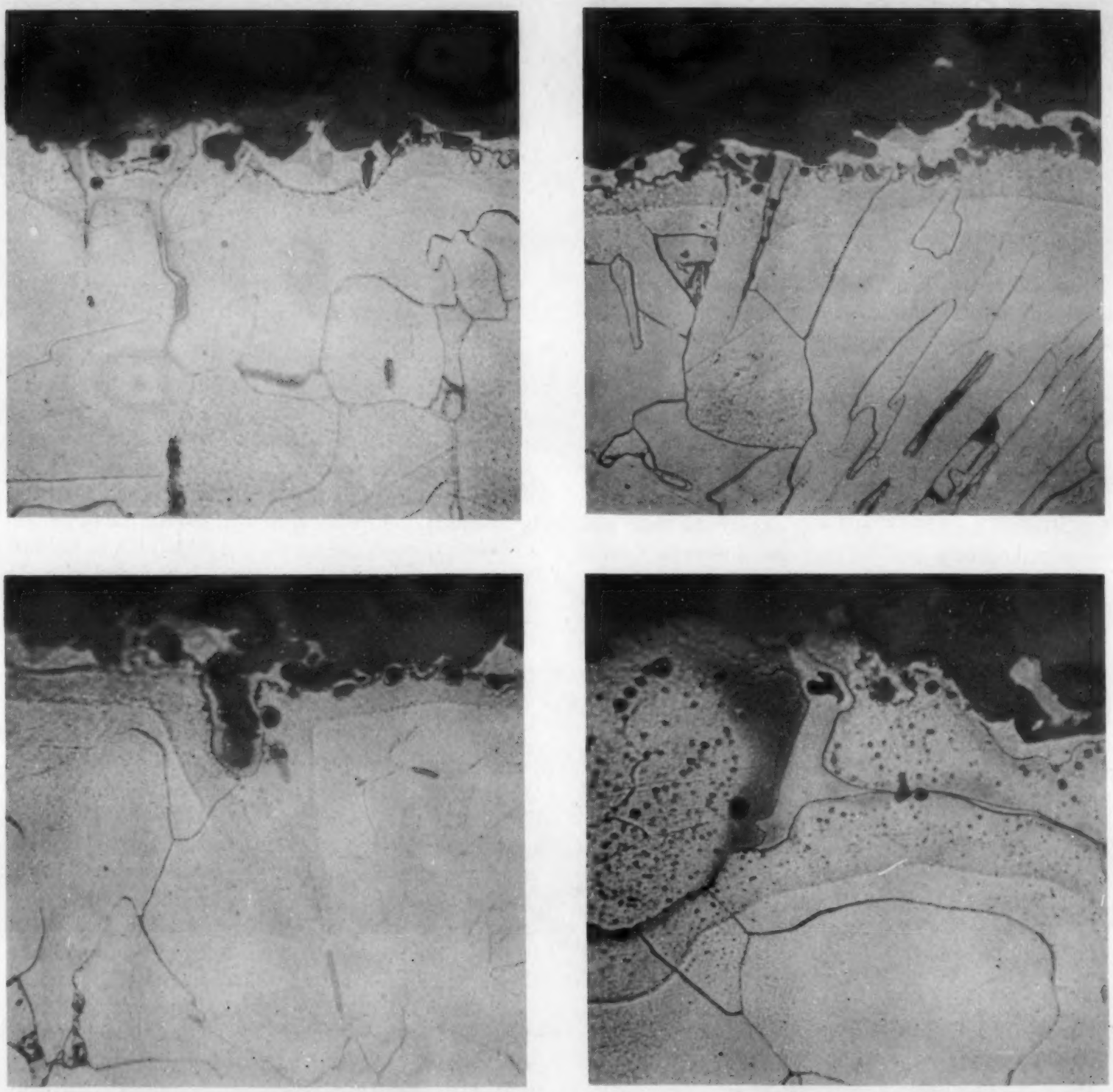


Fig. 3. Cross sections through the surface of copper-bearing steel (0.26% Cu) after 4 hrs.' soaking at 2,000 deg. F. Note outer layer of iron oxide followed by a second layer of iron-copper solid solution richer in copper which partially penetrated into the grain boundaries. Etched with nital. All 750 X except lower right hand, which is 1,375 X

drum plates and drum heads could not be increased to 0.30 and 0.20 per cent respectively. In the light of past experience this question would have been promptly answered in the negative, at least with respect to hot forming operations. However, bearing in mind that the surface cracking of these copper-bearing steels is also influenced by the severity of heating and hot forming conditions, it was decided to examine the practicability of higher copper contents in drum shell and drum head plates by suitable welding and forging tests.

In our 70,000 lbs. per sq. in tensile strength material for drum plates the permissible copper content is limited to 0.18 per cent and in the high tensile material for drum heads to 0.12 per cent Cu. A slightly higher copper content has been allowed for drum plate material because the latter does not have to undergo the same high degree of hot deformation as the material for drum heads which are hot forged to a very small radius. It has been observed that this copper-bearing steel seems to display a loss of ductility due to grain boundary weakening at temper-

atures where carbon migration and solution begin to occur, thus limiting the deformation which the material can stand at these temperatures.

Copper and Hair-Line Cracks

It has also been found in earlier investigations that the effect of copper in causing hair-line cracks in drum heads was more pronounced as the carbon content increased. All our early experience which led to the limitation of copper in drum plate and drum head material had been gained with 55,000 lbs. per sq. in. tensile material, and these copper limitations were also applied to the subsequently introduced 70,000 lbs. per sq. in. tensile plate material for drum plates and drum heads. How closely these copper limitations conform to actual shop experience became evident from a recent investigation of ten failed manheads. These manheads tore at the opening and some of them developed fine checks on the outer radius at both the manhead and the heel of the flange. A comparison of the copper content of the materials involved with the amount of checking observed—the checking is independent of the tearing during the forming of the manhole opening—revealed the following relationship:

Copper %	*Condition of Material*	
0.18	Bad checking	Same heat
0.15	Bad checking	
0.13	Checking	
0.12	Checking	
0.10	Checking	
0.10	Slight checking	
0.11	No checking	Same heat
0.11	No checking	
0.09	No checking	
0.10	No checking	

Experimental Material: The copper-bearing high tensile steel plate used in the subsequently described experiments analyzed:

C	Mn	Si	P	S	Cu	Ni
0.30	0.61	0.24	0.012	0.020	0.26	0.02

Four plates, 24 in. by 12 in. by 1½ in., were used. Their physical properties were:

Yield Point, lbs. per sq. in.	*Tensile Strength, lbs. per sq. in.*	*Elong. in 2 in., Per cent*
43,100	79,400	26.25
42,400	77,300	24.5

Test specimens stress-relieved at 1150 to 1200 deg. F. (holding time 1 hr. per in. of thickness), furnace cooled to 600 deg. F. and air cooled.

Welding Behavior

According to published reports, the maximum amount of copper permissible in steel without introducing difficulties in welding appears to be 0.80 to 1.00 per cent. The low copper-bearing steels employed in our fabrication never presented any diffi-

Fig. 4. Forge test specimen, ¼ natural size. Test piece of copper-bearing plate (0.26% Cu), 12 in. by 2 in. by 1¼ in. soaked at 2,000 deg. F. for 4 hrs., and both ends forged out until failure occurred. Forging of upper end interrupted at appearance of first crack, forging of lower end continued until fissuring occurred.

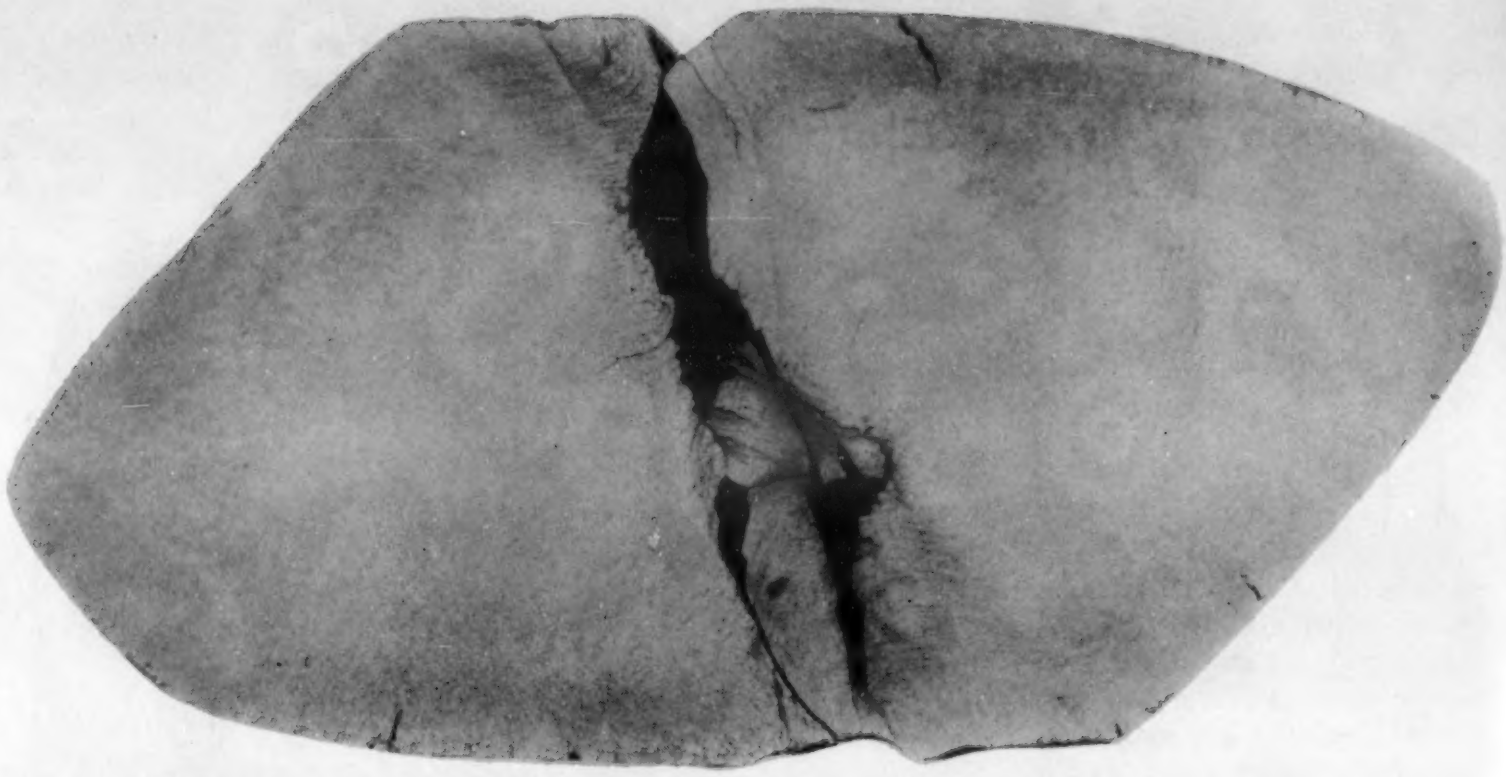
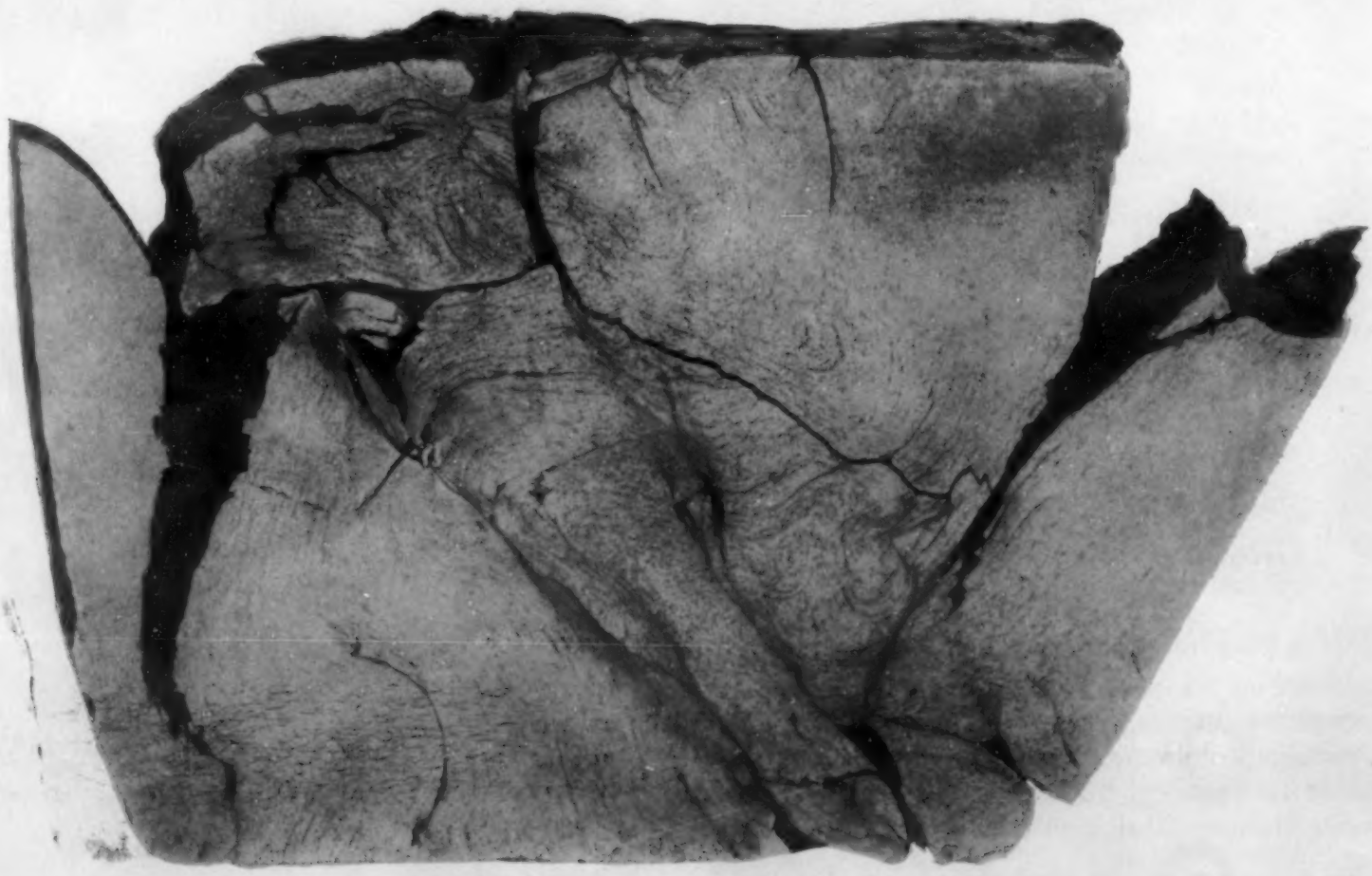


Fig. 5. Slightly enlarged macro-etched cross section through forged end of specimen depicted in Fig. 4 (upper end). Note deep surface cracks and metal rupture in the middle of cross section.

Fig. 6. Slightly enlarged macro-etched cross section through forged end of specimen depicted in Fig. 4 (lower end). Note complete fissuring of metal resulting from original surface cracks.



culties in welding. Nevertheless, two sample test welds were prepared in the 0.26 per cent Cu steel, employing two different types of electrodes. The two test plates were subsequently stress-relieved at 1200 deg. F. and tested with the following results:

(a) *Test Plate No. 1*

Electrode: 3/16 in. dia. Red Devil No. 85 at 220 amps.
X-ray examination: Sound weld with very slight porosity.
Transverse tensile strength: 79,100 (failure in weld metal) lbs. per sq. in.
All weld metal tensile properties—
Y.P.—64,000 lbs. per sq. in.
T.S.—78,000 lbs. per sq. in.
Elong. in 2 in.—27.0 per cent
Red. of Area—60.0 per cent
Weld Bending Properties: Angle of bend—150 deg.
Radius of bend—0.85 in.
Elong. at weld—32.0 per cent

(b) *Test Plate No. 2*

Electrode:
First three beads 3/16 in. dia. Wilson #105-220 amps.
Remainder of weld 3/16 in. dia. Red Devil #85-220 amps.
X-Ray examination: Sound weld with very slight porosity.
Transverse weld tensile strength: 78,260 lbs. per sq. in.
All weld metal tensile properties—
Y.P.—72,000 lbs. per sq. in.
T.S.—81,000 lbs. per sq. in.
Elong. in 2 in.—26.5 per cent
Red. of Area—59.8 per cent
Weld bending properties: Angle of bend—170 deg.
Radius of bend—0.65 in.
Elong. at weld—42.0 per cent

The welding of the two test plates presented no difficulties. There was no indication of red-shortness or cracking in weld metal and heat-affected zones. The weld properties are to be considered satisfactory.

Hot Forming Under Severe Conditions

It has been pointed out previously that the severe deformation involved in the forging of drum heads caused most of the difficulties encountered in the hot forming of copper-bearing steel. The forging characteristics of copper-bearing plate were investigated under two sets of conditions; i.e., under very severe conditions, as may be encountered due to exceptional circumstances, and under normal fabricating conditions for drum heads. The following forging tests were carried out under *severe* conditions:

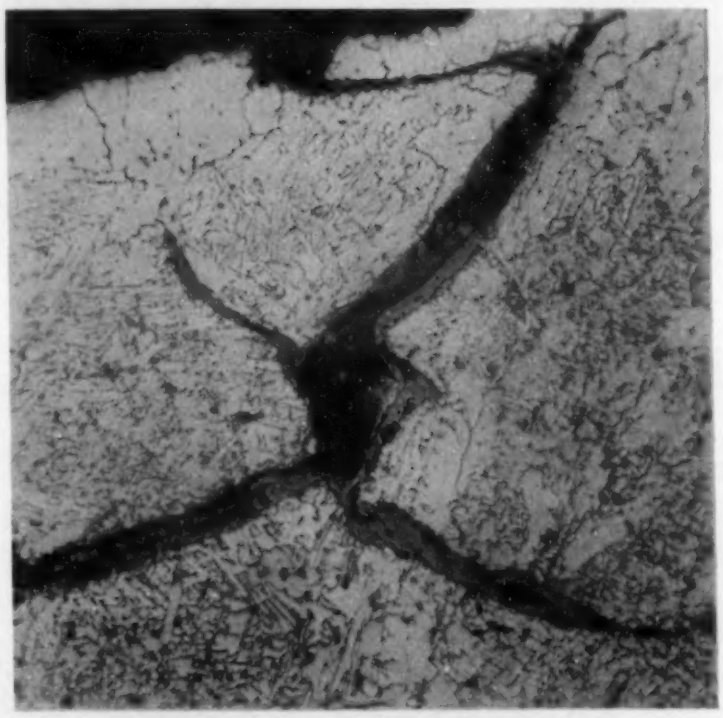
(a) Effect of prolonged soaking at maximum forging temperature upon the surface structure:

All test pieces were heated to the maximum permissible forging temperature of 2000 deg. F. and held at this temperature for 4 hrs. This holding time is exceptionally long and is usually not encountered in our fabrication. For a plate of 1½ in. thickness a holding time of 1 to 1½ hrs. may be considered as normal. The effect of this long holding time at the maximum forging temperature upon the surface of the copper-bearing steel was microscopically studied. Intergranular penetration, similar to that depicted by Gregg and Daniloff[2] was clearly evident.

(b) Hot Bending Properties after Prolonged Soaking at Maximum Annealing Temperatures:

Hot bending characteristics of the copper steel after 4 hrs. soaking at 2000 deg. F. are demonstrated

Fig. 7. Cross section through surface of forge test specimen depicted in Fig. 4 (upper end) showing origin of cracking in intercrystalline surface weakness. Note intercrystalline oxide penetration. Etched with nital, 300X.



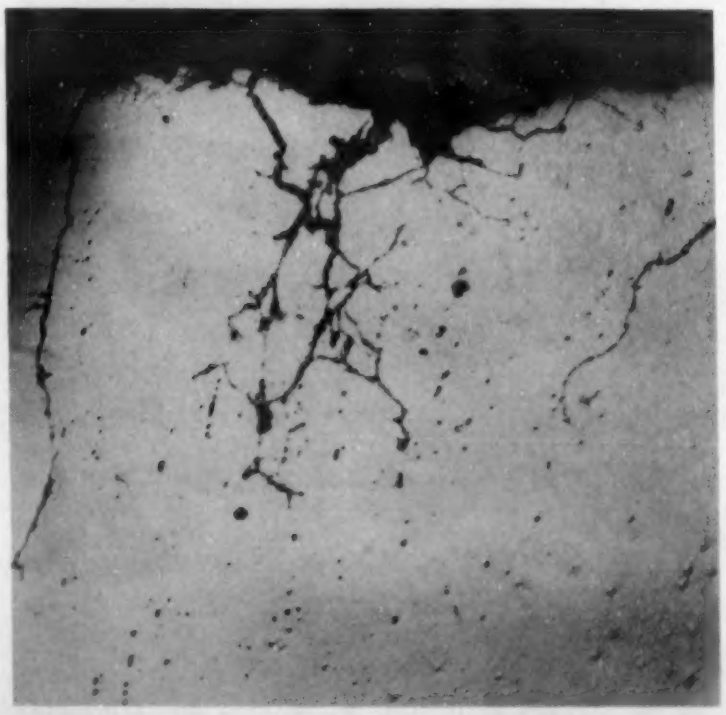


Fig. 8. Same as above at lower magnification showing progressive trend of surface cracks. Unetched. 100X.

by the bend test specimen depicted in Fig. 1. This test piece consisted of a strip of plate 12 in. by 2 in. by 1¼ in. After a 4-hr. soak at 2000 deg. F. one end of the specimen was flattened to approximately one-half of its original thickness and the piece then bent back on itself and compressed. This operation was finished at approximately 1650 deg. F. The flattened leg of the specimen opened up into two cracks during the flattening. The more severely deformed surfaces displayed a deeply wrinkled appearance. A slightly enlarged cross-section through the bent surface is depicted in Fig. 2, which shows that the surface wrinkles consist of shallow intercrystalline cracks of a maximum depth of approximately 0.025 in. The nature of the latter is more clearly evident from Fig. 3 representing the microstructures of sections through the bent surface. This bend test demonstrates that the higher copper content, although not critically affecting the hot bending properties of the steel, produces shallow surface tears which may develop into more serious defects if the finishing temperature is allowed to drop below 1700 deg. F.

(c) Forging Properties after Prolonged Soaking at Maximum Forging Temperatures:

The forging characteristics were investigated. A specimen 12 in. by 2 in. by 1¼ in. was heated to 2000 deg. F. and held at this temperature for 4 hrs. The test piece was then removed from the furnace and both ends forged out. The forging was interrupted when the first crack appeared at the one end of the specimen, and at the other end when serious fissuring occurred. The estimated temperature at which these failures took place was 1200 and 1100 deg. F., respectively. The forged test specimen is depicted in Fig. 4. Macro-etched cross sections through the forged ends are shown in Fig. 5 and 6. The latter demonstrate that the shallow surface tears which were formed during the prolonged heating prior to the forging develop into serious surface cracks when the forging temperature reaches too low a value, and finally lead to ruptures in the metal. It is estimated that the lowest permissible safe finishing forging temperature lies in the neighborhood of 1700 deg. F., depending on the severity of the forging operation involved. The development of the original intercrystalline surface tears into cracks is illustrated in more detail by Fig. 7 and 8. *(To be concluded)*

References

[1] Sullivan, J. D. and A. E. Pavlish. "Residual Metals in Open-Hearth Steel," *Metals and Alloys* Vol. 10, 1939, pp. 184-186.

[2] Gregg, J. L. and B. D. Daniloff. "The Alloys of Iron and Copper." McGraw-Hill Book Co., New York, 1934, pp. 87-97.

Letters to the Editor

Russian Technical Literature

To the Editor: The Science-Technology group of the National Special Libraries Association has undertaken to compile, for the benefit of users of the Russian scientific and technical periodicals, current or otherwise, a complete list of the holdings of such periodicals in all the libraries of the United States and Canada as far as possible, whether personal, institutional or industrial. Owners and librarians in charge of such materials are asked to coöperate by sending a detailed statement of their holdings to Miss Nathalie D. Frank, 512 West 162nd St., New York City. Please state also whether the journals can be borrowed on interlibrary loan and whether the library has facilities for photostating or microfilming.

EMMA C. CRANDAL
Librarian

Universal Oil Products Co.,
La Grange, Ill.

Correcting a Press Report

To the Editor: Recent press reports that materials such as tooth paste can be kept in collapsible tubes made from lead without becoming contaminated are not true. The press drew this conclusion from a paper presented at a recent meeting of the American Institute of Mining and Metallurgical Engineers under the authorship of myself and Messrs. Markus and Grobe. This paper demonstrated that in carbonate solutions in the pH range from 9.5 to 11.2 the tin-lead couple is under cathodic control and the anodic elements are tin. The effect of several addition agents was also demonstrated.

The experiments did not deal with any commercial material such as tooth paste or shaving cream, and the corrosion properties of lead alone were not discussed. There is of course no scientific justification for applying the results obtained for the lead-tin couple in carbonate solutions to uncoupled lead in any other environment.

In order to avoid cases of lead contamination, it is important that these facts should be disseminated as widely as possible by scientists who are qualified to understand their implications.

GERHARD DERGE

Metals Research Laboratory,
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Brake Drums—III

By OLIVER SMALLEY

President, Meehanite Metal Corp., Pittsburgh

The first two parts of this article, published in February and March, discussed brake drum materials in general and their service requirements. This concluding instalment summarizes the results of performance tests on 4 brake drum irons and offers some useful observations on scoring and thermal checking.—The Editors.

Test Drum No. 4

Of this series of test drums, one more might be considered in that the use of such materials as nickel, copper, and molybdenum in combination with small quantities of chromium are commonly recommended in cast iron for heavy duty truck and bus drums where strength, high resistance to thermal checking and scoring are most important. Unfortunately, most alloy drums contain only too frequently some free cementite, and while this may not be massive, nevertheless its effect under the tests now being considered is of more than ordinary interest. The composition of the series of drums used was:

	Per Cent
Total carbon	3.26
Silicon	1.92
Manganese	0.86
Sulphur	0.098
Phosphorus	0.108
Nickel	1.23
Chromium	0.25

The actual Brinell taken from the drums themselves was 227, and the tensile approximated 42,300 lbs. per sq. in.

Photomicrograph, Fig. 32, shows that the graphite structure is, on the whole, good. It is not so good a structure as Fig. 16, but is distinctly better than Fig. 26. Photomicrographs, Figs. 33 and 34 reveal the etched structure at 100 and 500 magnifications respectively.

As would be expected, they display an exceptionally good close type of pearlite as would confer superior resistance to scoring, whilst the cementite patches are of minute form and well distributed. Such a structure would be acceptable to most foundry engineers experienced in the manufacture of alloy brake drums.

The appearance of this drum after dynamometer tests is shown in Fig. 35. It has a low rating in resisting thermal checks, but obtained a high rating in the scoring test.

Photomicrographs, Fig. 36 and 37 taken at 100 and 500 magnification respectively indicate that thermal cracks in this iron were less inclined to follow the graphite flakes than in the previous sample.

The normal surface seemed to hold up until once the cracks were formed and then they penetrated deeply into the interior of the drum. In this example, penetration of the cracks was deeper than in any of the others tested.

Photomicrograph, Fig. 38, shows the structure of the surface of the drum at 500 magnification after the thermal check test, indicating that the pearlite resisted decomposition better than any other example cited. The presence of the heavy coating of oxide of iron surrounding the cracks clearly reveals the high temperature this drum must have reached in test.

Summary

These tests made on the Timken dynamometer are instructive because they demonstrate the effect of both composition and microstructure on the service of brake drums under identical conditions. Each illustrates its own story of the mechanism of the breakdown of brake drum metal.

Scoring: This is shown to take place when the temperature gradient developed in the drum is not steep enough to set up the mechanism of reversal of expansion and contraction of the metal itself to which reference has previously been made.

Scoring appears to proceed by frequent applications of the brake so that the heat from the last application is not dissipated completely—that is, any condition of braking which makes the drum do more work than originally intended of it.

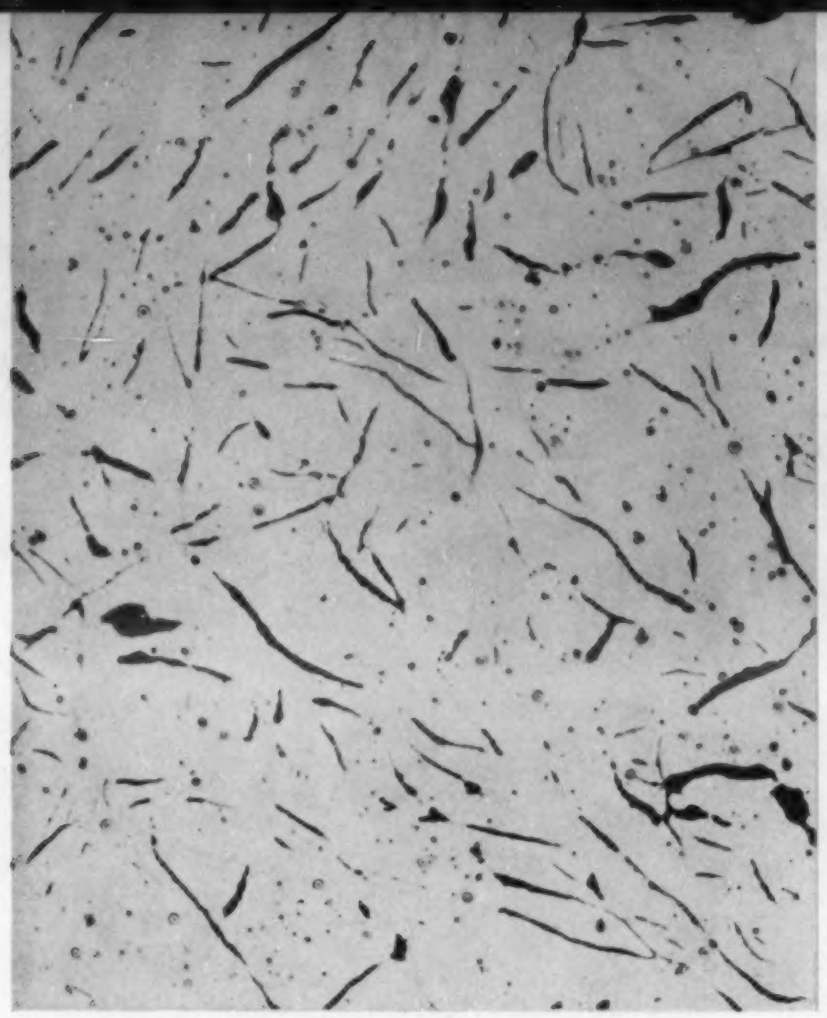


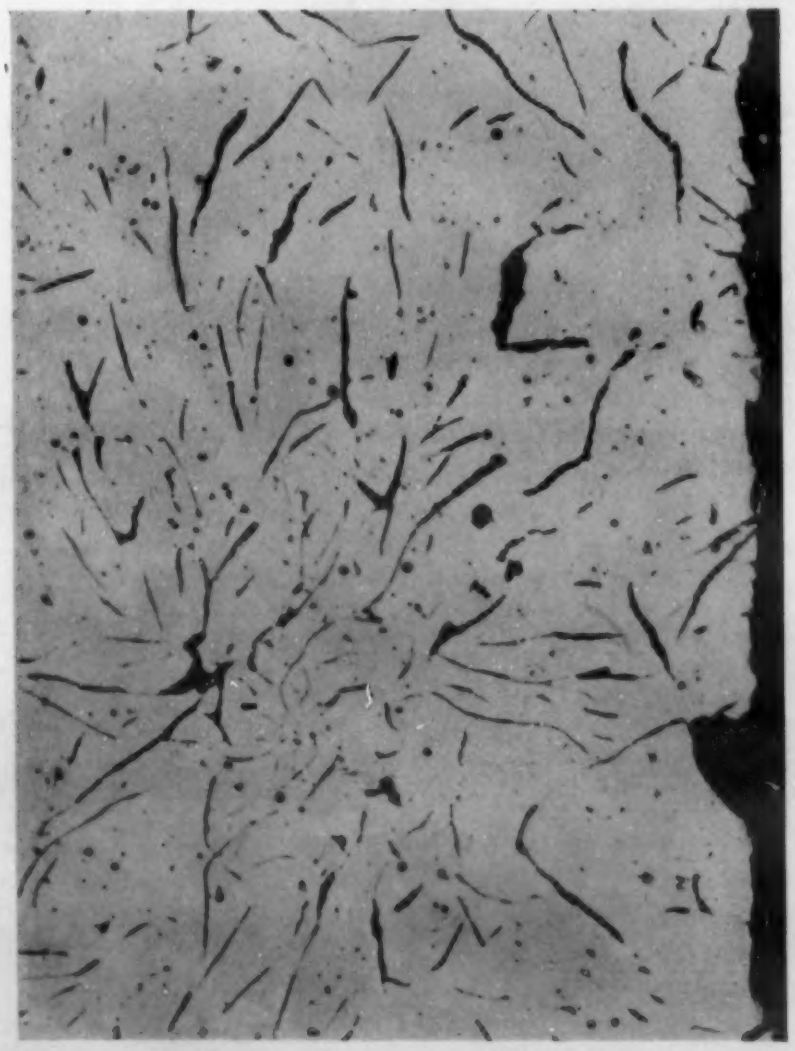
Fig. 32. Structure of graphite. 100X.

Fig. 33. Same as Fig. 32 but etched. 100X.

Fig. 36. Normal graphite structure of the drum before the tests. 100X.

Fig. 37. Graphite structure of the surface of the drum after the test. Unetched. 500X. Same iron as Fig. 36.

Working Surface of Drums



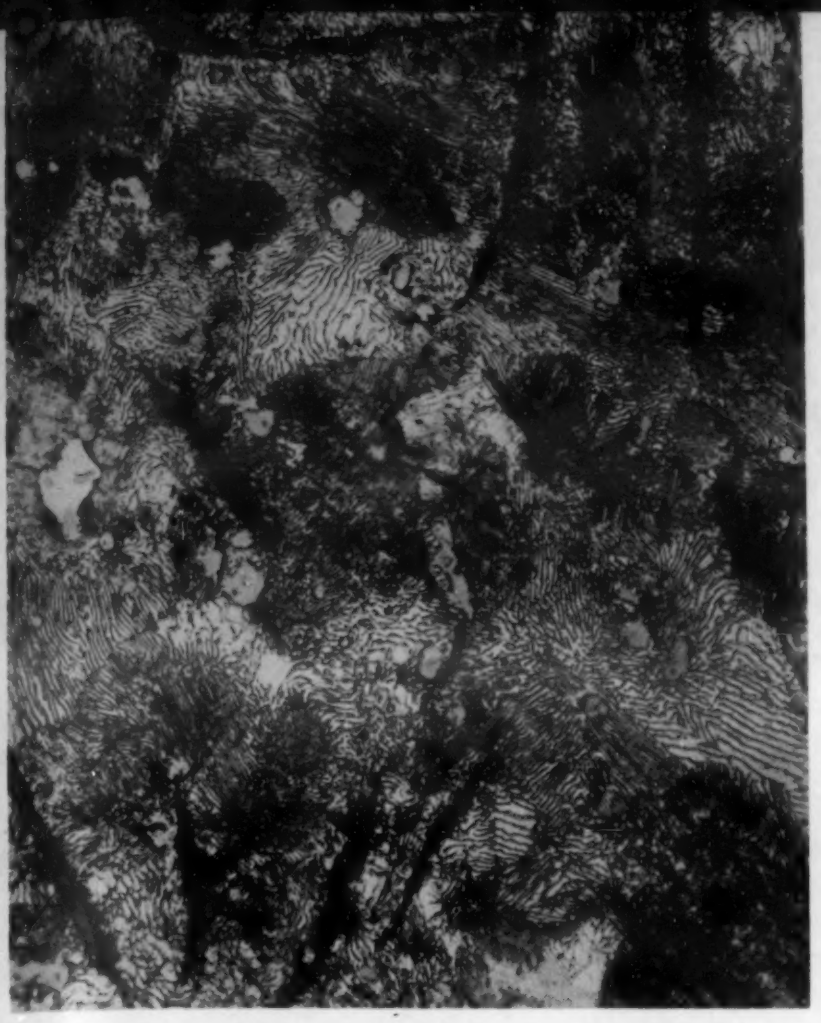


Fig. 34. Same as Fig. 32 but 500X.

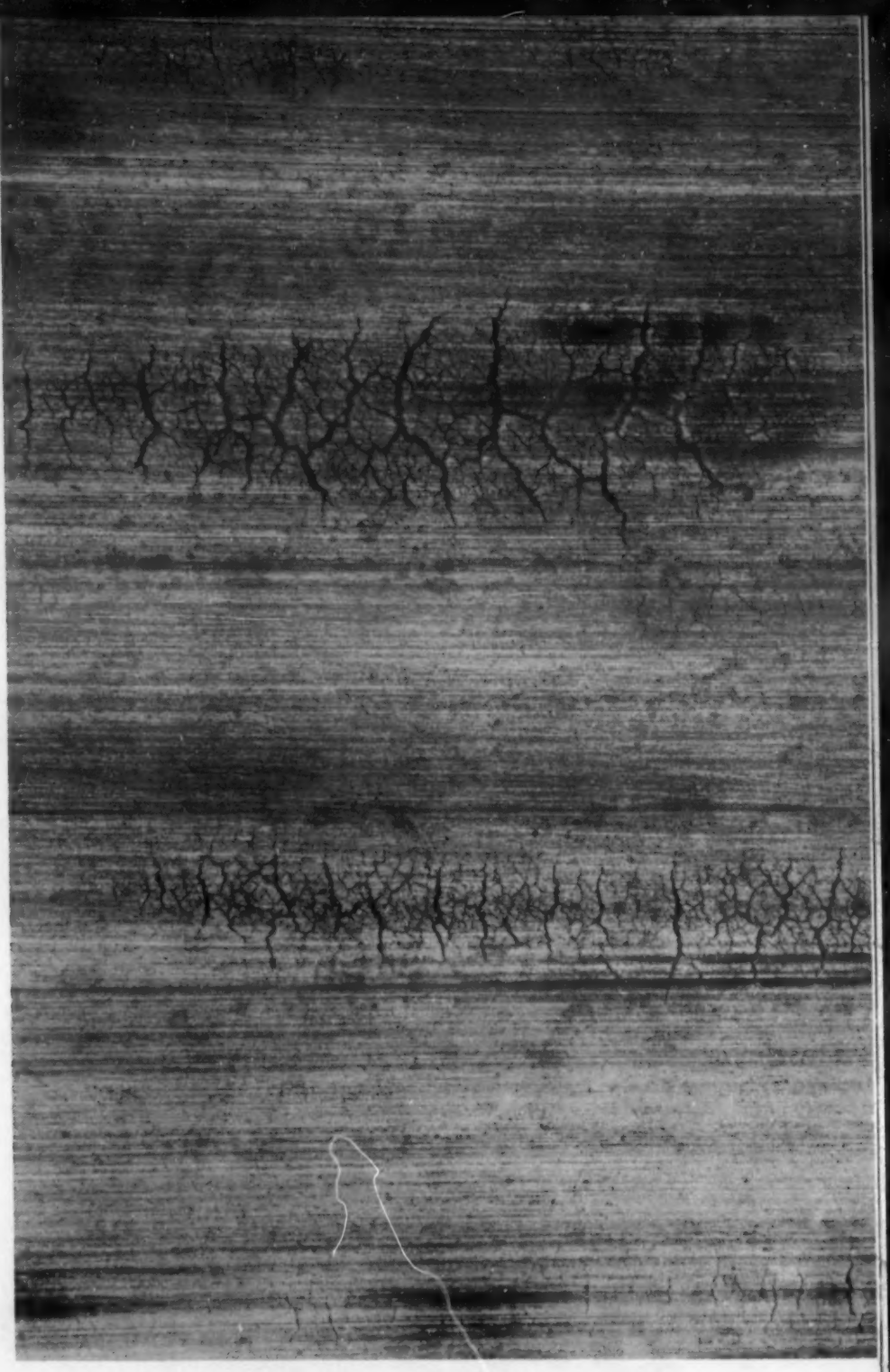


Fig. 35. Appearance of the drum after dynamometer tests.

Fig. 38. Etched structure of the surface of the drum after the test. Same iron as Figs. 36 and 37. 500X.

Scoring also bears some relation to relative hardness of the lining and the drum. Everything else being equal, a hard drum of the correct graphite structure will score less than a softer drum.

Other causes of scoring have been dealt with earlier in this paper.

Thermal Checking: This occurs when the temperature gradient between the braking surface and the center of the drum is too steep for the drum to take care of. These tests indicate surface heating well above the critical change point.

Apart from selection of a metal of such structure as will enable it to accommodate itself to alternating stresses at elevated temperatures, design of the drum, selection of the lining and adequate ventilation are all contributing factors.

Possibly the most important lesson of these tests is to show that any study of brake drum materials must be made under conditions approaching actual service operations as nearly as possible.

To change the nature of a lining or the design of the drum or conditions of braking without making a new series of tests might be apt to give materially different results. It is this factor that makes the whole brake drum problem so difficult.

Today not only the mechanical features of braking are changing rapidly but vigorous research is being conducted by both the foundries making the brake drums and the manufacturers making the linings. Today so many compositions and structures of drums and linings are available that the only intelligent method seems to be that followed by Timken-Detroit Axle and the Fruehauf Trailer and such companies who are constantly conducting tests under closely controlled conditions.

But even this presents certain problems, for both the brake mechanism and the materials from which they are made are a long way from the ultimate.

Cast iron, while possibly the best of cheap brake drum materials, is still an indeterminate. Cast iron brake drums of practically identical chemical composition may not possess the same structural make-up or the same physical properties. One batch may exhibit coarse graphite and some ferrite in a base structure of pearlite; another batch made from the same mixture and the same analysis may present an open pearlitic or even a closely pearlitic base structure with a different form of graphite according to the degree of metallurgical control operating in any particular foundry and according to their methods of pouring and molding.

Mostly all brake drum irons made with alloys, particularly those containing chromium, contain some free cementite and, as was shown, each structure responds very differently to scoring, thermal checking, and ultimate service life.

The primary considerations of a good brake drum material are:

1. To select the correct structure in combination with the best mechanical properties for the particular service conditions to be encountered.
2. Uniformity—that is, every brake drum must have the same structure regardless of design or dimension.

In the absence of these, fancy compositions of irons, the indiscreet use of alloys, the claim for high strength tests and the loose use of metallographic terms are apt to be more misleading than informative.

For example, brake drums on a logging trailer in the mountainous regions of the Northwest of this country call for an exceedingly hard wearing iron. The service is so severe on the long mountain grades that a tank of water is mounted on the trailer for the purpose of cooling off the drums.

Such service and treatment produces both severe wear and premature thermal cracking.

For such a drum, a close form of pearlite that is thermally stable and a uniform and well-distributed condition of graphite structure will give the best results. Anything softer than this wears away rapidly while excessive use of alloys producing free cementite causes deep thermal cracking and surface hardening.

In the case of ordinary trailer drums, the problem is primarily one of providing adequate stopping ability in view of the present tendency of over-loading trailers. This is further complicated to a certain degree by preference for having the trailer brakes operate ahead of and more powerfully than those on the tractor.

In other words, trailer brakes are generally expected to do more work than those on the tractor. This may mean the use of a special high friction block, and such a material would cause rapid failure of drums having the structure shown by No. 3 and 4 materials used in the above tests.

On the other hand, for city bus drums where braking is relatively light but of high frequency, heat gradients from the braking surface to the center of the drum are not so high as would be developed in the heavy braking of a loaded trailer, hence resistance to scoring is more important than resistance to thermal checking although a nice balance is necessary. Thus it will be seen that an iron successful in one kind of service may fail in another.

It is for this reason that Meehanite is finding wide favor in the manufacture of brake drums of all kinds, for this process renders available not only the control of both the structure and properties best suited to a particular service condition, but it enables quantity production under absolute and positive control. In other words, each type of Meehanite brake drum is made to a pre-determined structure and every drum made from that type of Meehanite will have exactly that structure and no other. Hence, when braking conditions have once been determined in the way of design, nature of brake lining, etc. a good wear resisting curve of both the lining and drum is assured and braking surfaces remain flat and smooth.

Malleable Beryllium

by G. E. CLAUSSEN and J. W. SKEHAN

Metallurgist and Factory Manager, respectively, Machlett Laboratories, Inc., Springdale, Conn.

Although beryllium is most familiar as the essential alloying constituent of certain age hardening alloys of copper and aluminum, the pure metal, too, has a growing commercial application for "windows" of X-ray tubes. Ideally, beryllium for such use should be vacuum-tight, malleable to permit forming in thin sheet, and ductile at high temperatures to facilitate brazing. Actually, however, beryllium has heretofore resisted all attempts to render it malleable through enhancement of its purity. This article reports the successful production of malleable beryllium containing small amounts of titanium and zirconium, and describes the processing technique employed.
—The Editors.

AMONG THE CUBIC AND HEXAGONAL METALS there are few that have not been rendered ductile or malleable by purification. Beryllium is one of the metals that has not become malleable despite successful attempts at raising the purity very close to 100 per cent. Besides raising the purity through refined methods of reducing the metal from the ore and through distillation of vacuum-melted metal, attempts also were made to secure hot workability through grain size in this laboratory. Fine-grained as well as coarse-grained castings of vacuum-melted beryllium lacked malleability.

Since the lack of malleability of beryllium appeared to be caused by films of a material believed to be beryllium oxide, a number of elements were alloyed with the beryllium in an effort to remove the films. Of a number of alloying elements that were investigated, titanium and zirconium were successful and beryllium treated with a little of these elements can be hot worked satisfactorily.

The present research was undertaken to secure thin vacuum-tight beryllium about 0.004 to 0.020 in. thick with some ductility at elevated temperatures for windows of X-ray tubes. Hot ductility was desirable to resist thermal and clamping stresses during brazing without cracking. Furthermore, to produce

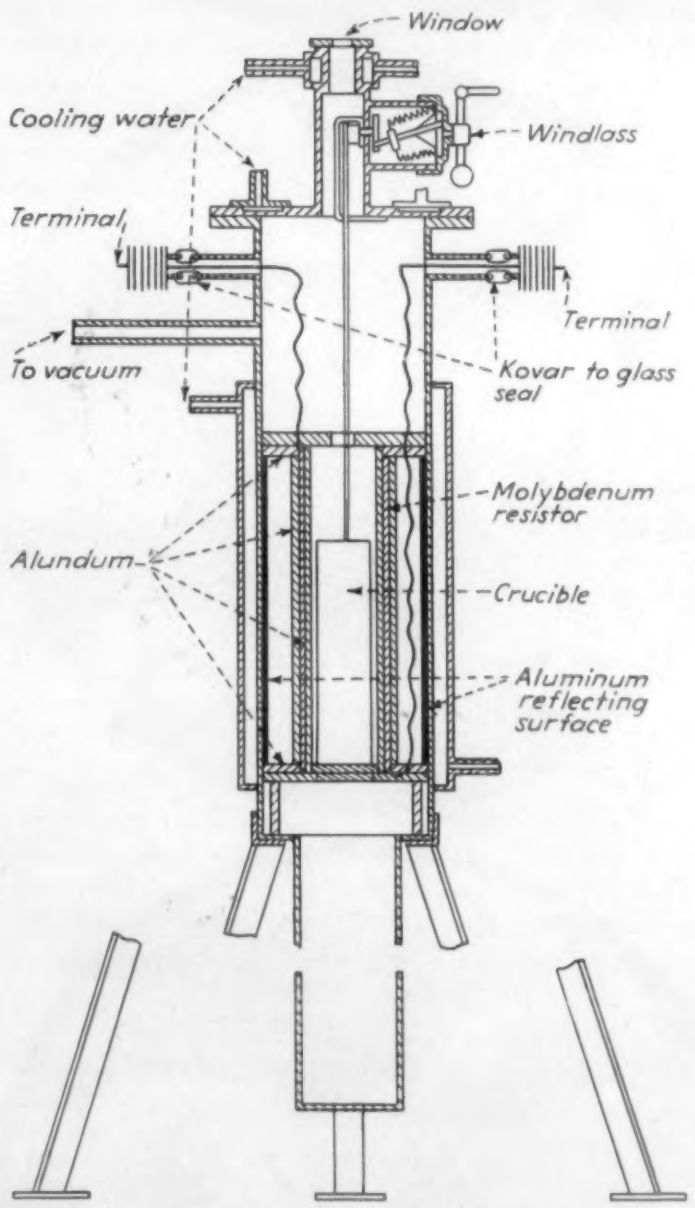


Fig. 1. Vacuum furnace with molybdenum resistor for melting beryllium. The sylphon windlass permits the crucible to be raised or lowered for rapid cooling and permits the observer to agitate the melt. The inner wall of the furnace was lined with polished aluminum sheets. The inner alundum tube cooled from 1,400 to 600 deg. C. in an hour.

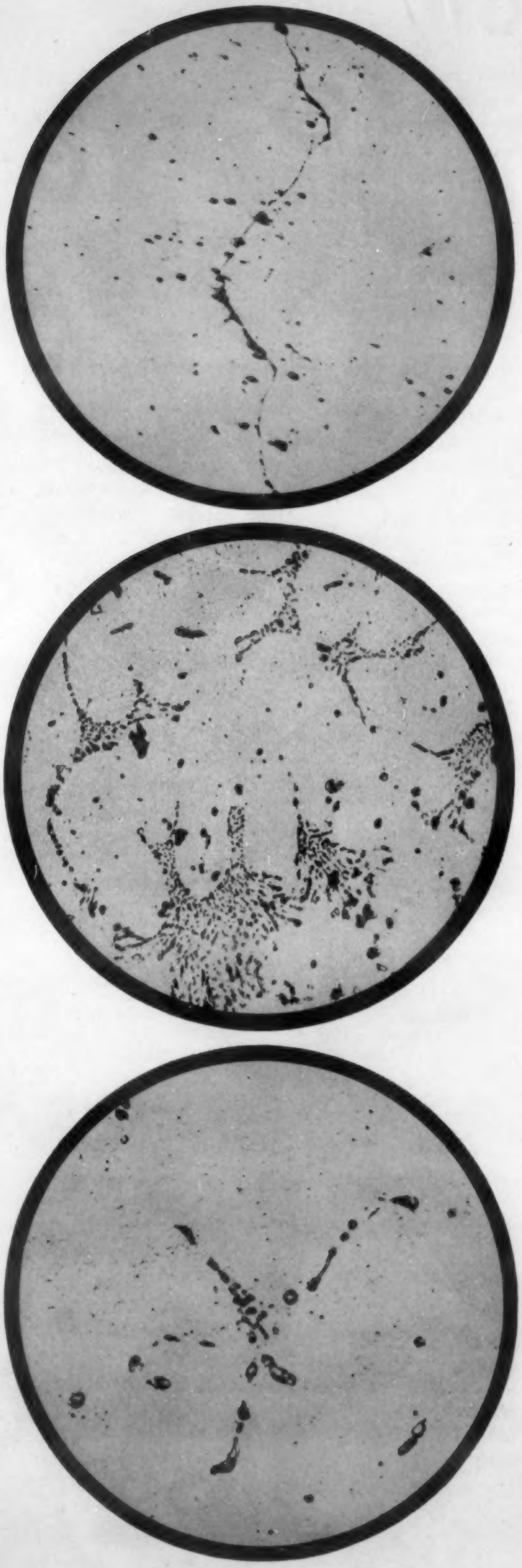


Fig. 2. (a) Micrograph showing films that destroyed the hot workability of beryllium. Unetched. 100X. (b) Microstructure of beryllium to which 1/2 per cent titanium was added. Etched with 50 per cent hydrofluosilicic acid. 500X. (c) Microstructure of beryllium to which 1/4 per cent titanium was added. Etched with 50 per cent hydrofluosilicic acid. 500X.

thin beryllium in curved or cupped form, it was essential to have malleable metal because machining or grinding thin parts of beryllium, which is brittle at room temperature, is scarcely practicable. Vacuum tightness and malleability are important properties for a metal to be used as windows in X-ray tubes, for which the low atomic number of beryllium renders it particularly suited. In the past, beryllium windows having been used within the glass envelope of the X-ray tube, vacuum-tightness was unnecessary. The new malleable beryllium, however, makes it possible to produce X-ray tubes with beryllium windows serving as part of the envelope. Other properties of the metal are listed in the Table. The following account describes experiments conducted at Machlett Laboratories, Inc.

References to earlier attempts at producing malleable beryllium are summarized by Sawyer[1] and Stott.[2] Sawyer reports the mechanical properties of forged beryllium, but did not describe the method and product. Tensile specimens had tensile strengths of about 30,000 lbs. per sq. in. with zero elongation. Beryllium X-ray windows were die forged in 1926 and a recent patent refers to forging vacuum-cast beryllium at 50 to 100 deg. C. below the melting point. Stott mentioned that the hot rollability of distilled beryllium was poor and the edges of the rolled sheets cracked considerably. Similar lack of success with distilled beryllium was described by Kroll.[3] Sloman[4] likewise observed that the metal had some malleability and blamed the grain-boundary eutectic of Be-BeO for the cracking of the highly purified metal during hot working.

Raw Material and Furnaces

The raw material was commercial beryllium metal made by Brush Beryllium Corp., Cleveland, containing, according to spectrographic analysis (arc process with carbon electrodes burning until sample was consumed): 0.1-10 per cent Mg, 0.001-0.1 per cent Al, 0.001-0.1 per cent Fe, up to 0.01 per cent Si, up to 0.01 per cent Cr, up to 0.01 per cent Mn.

No entirely satisfactory fluxes being at hand to permit melting in air, vacuum melting was selected. Non-reactive atmospheres such as hydrogen possibly may be used as well as fluxes. Any method of melting, such as under hydrogen or a flux in which the beryllium was out of contact with a reactive atmos-

phere, might have been as satisfactory as vacuum melting. Two vacuum furnaces were used, both involving rubber gaskets that remain cool during operation. In the first furnace the crucible was inside a Pyrex container 3 in. in diameter and was heated by a high frequency coil. The second furnace, Fig. 1, consisted of a welded steel casing within which was a molybdenum-wound alundum heating tube. The head was cooled internally by flowing water. Both furnaces were fitted with oil diffusion pumps (the use of which will be described later) and with viewing glasses at the top for temperature measurements with an optical pyrometer.

When a vacuum of 1 micron had been drawn on the glass furnace, heating was commenced, the vacuum falling to 0.4 to 0.5 mm. when a charge of raw metal was being melted. A charge of 200 grams could be melted in 20 to 30 mins. After melting had occurred and reactions such as volatilization of magnesium in the melt had ceased, the vacuum rose to 0.005 to 0.05 mm. The heating of the resistance furnace occupied 6 hrs. and the pressure never exceeded 0.05 mm., the melt being frozen under a pressure of 10 to 20 microns. If the vacuum was poor, the metal became coated with white powder (oxide).

Refractories

Beryllium can be melted without detectable contamination in crucibles of beryllium oxide or graphite. As Stott states, and our experiments confirm, zirconium oxide crucibles are unsatisfactory because beryllium reduces the crucible, and the melt is rapidly contaminated with zirconium. Graphite was satisfactory in the resistance furnace at temperatures as high as 1,380 deg. C. In the high frequency furnace, arcing between charge and crucibles often raised the temperature sufficiently to convert the melt to carbide. Graphite crucibles that had been used for melting beryllium acquired a surface layer of brown carbide which decomposed to a gray powder upon exposure to air for some time.

The beryllium oxide crucibles (2 in. diam., 3 in. high, 1/8-in. wall) were compressed in steel molds in a hydraulic press using a mix of beryllium oxide calcined at about 1,500 deg. C. (mainly 100 to 200 mesh) with an aqueous solution of beryllium salts (chloride) as binder. The crucibles were heated 2 hrs. at 200 deg. C. before being fired for 2 hrs. at 1,100 deg. C. The density of the crucibles was 1.7 compared with 3.0 for massive beryllium oxide. After repeated melts no reaction of beryllium with the crucible could be detected. Part of the surface of a melt usually adhered tightly to the crucible.

Self-Pouring

Since melts frozen in the crucible had large shrinkage cavities, the self-pouring principle was adopted to produce bars 1 in. diameter and 4 in. long. The charge for self-pouring was a single block of beryllium and was held in a crucible, the bottom of which was drilled to 1 in. in diameter. Below the hole in the crucible was fitted a tapered ingot mold of beryllium oxide or graphite. When the beryllium had melted, the thin but strong envelope of oxide surrounding the melt prevented it from flowing through the hole for a minute or two. Eventually the metal flowed through the hole in the bottom of the crucible into the ingot mold. The metal remaining in the crucible acted as a shrink head to prevent piping of the ingot. If the charge consisted of several lumps, they did not always self-pour simultaneously and, in any event, the ingot generally consisted of several sections separated by oxide films. The bottom of an ingot consisted of fine grains characteristic of chill casting, whereas the upper inch or two of the ingot consisted of a few large grains extending into the shrink head.

Instead of self-pouring, several melts of beryllium were bottom poured by means of a plug. The tapered beryllium oxide plug fits into a hole in the bottom of the crucible, whence it is withdrawn at the proper moment by means of wires and windlass. The wires must be coated with beryllium oxide to prevent reaction with beryllium.

Distilling

In view of the high purity of the beryllium (99.9% plus) after vacuum melting, which lowers the magnesium content to one part per million or less, according to spectrographic analysis, it was not expected that distillation or sublimation would greatly improve the purity. Notwithstanding, about 200 grams of beryllium were distilled in several attempts. A charge of vacuum-melted beryllium was placed in a beryllium oxide crucible 2 in. in diameter and 2 in. high. A tightly fitting funnel of beryllium oxide was placed on top of the beryllium. The funnel was 1 in. thick and tapered from 1 1/2 in. inside diameter at the bottom to 3/8 in. inside diameter at the top. The funnel prevented nearly all spattered droplets of beryllium from entering the hood and prevented overheating of the hood. The hood on top of the funnel was 4 in. high and 2 in. diameter and had a hole 3/8 in. diameter in the top for measurement of temperature of the melt with an optical pyrometer.

The distillate from 100 grams of beryllium after 2 hrs. at 1,550 deg. C. (vacuum of 0.05 mm. Hg) weighed about 40 grams. The distillate at the top of the hood was sublimed metal, Fig. 3, consisting of myriads of tiny crystals of beryllium. Lower in the hood near the funnel was some sublimed metal that had melted or some distillate itself. Close to the funnel there was no beryllium on account of the high temperature. Neither sublimed metal nor distil-

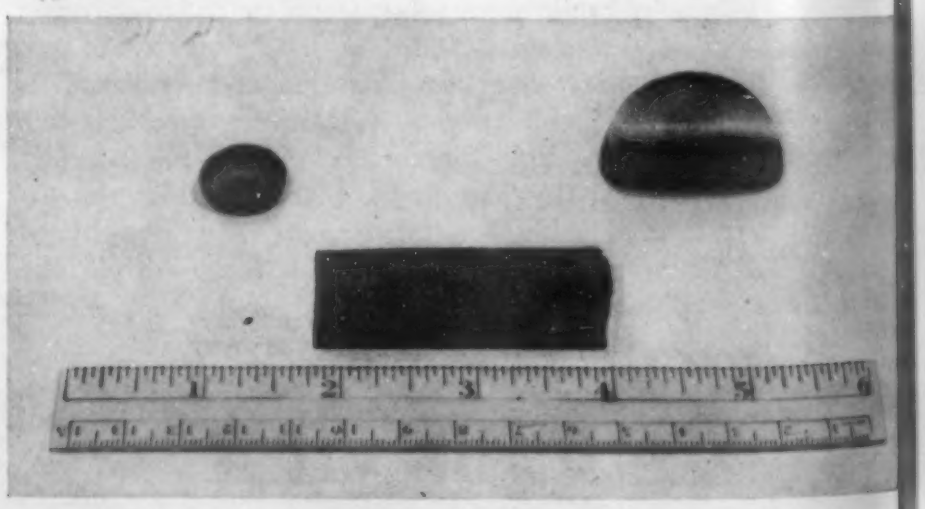
late was sound. The sublimed crystals did not cohere, while overlapping oxide films were trapped in the portion that had been molten. Small particles of distillate (45 Rockwell B) hot rolled well, but no success was had with large masses of distillate. Upon being remelted the distillate became contaminated with oxide films to the same extent as undistilled metal. Great difficulty was experienced in securing a sound melt from sublimed crystals. Each crystal seemed to be covered with a film of oxide which completely prevented coalescence during remelting. Distillation had little effect on the purity of vacuum-melted beryllium aside from reducing the aluminum content to less than 0.001 per cent, according to spectrographic analysis.

Fig. 3. Vacuum-distilled beryllium. In the background is the metal from the top of the hood. In the foreground is metal nearer the funnel.

Fig. 4. (a) Unsuccessful attempt at hot rolling a disc from an ingot of unalloyed beryllium that had been vacuum melted and self-poured. (b) Hot worked titanium-treated beryllium. (Left) A cup 11/16 in. outside diameter, 0.030 in. thick, 1/8 in. high, drawn hot from a disc. (Middle) A hot rolled sheet 0.004 in. thick rolled from a cast disc 1/8 in. thick. (Right) A hot rolled disc 0.020 in. thick curved to 1 in. diameter.

4a

4b



Alloying

To alloy beryllium with titanium, the titanium was placed on top of the vacuum melted beryllium. At a temperature a little below the melting point of beryllium a reaction occurred, the titanium and metal in its vicinity melting and rising rapidly in temperature. After a few minutes, the hot reaction area spread across the melt, which became uniform in temperature once again. The surface of self-pouring ingots of beryllium-titanium alloy was freer from oxide than similar ingots without titanium.

While the function of titanium in beryllium is not known completely, some speculations on its probable action may be offered as follows: Beryllium, whether distilled or melted in vacuum, has been found to contain films of a material which is believed to be oxide. The films separate masses of otherwise hot-workable metal and are the surfaces of failure in unsuccessful attempts at hot rolling. The films have the characteristics of the extremely thin film of oxide coating the surface of vacuum-melted beryllium. The surface films of each individual lump of beryllium become trapped in the solidified metal owing to their thinness, their strength, and their specific gravity (3.0), which is higher than that of beryllium itself.

To rid vacuum-melted beryllium of its films, a small amount of titanium is added, 1/2 per cent or less being adequate for vacuum melts (self-pouring type) in beryllium oxide crucibles. In these small percentages in the liquid alloy, the titanium is soluble at temperatures near the melting point of beryllium. The titanium reacts with what is believed to be BeO at the temperatures and pressures of the self-pouring process. In the reaction titanium reduces some of the beryllium oxide to beryllium and

Table of Some Properties of Beryllium

Atomic number:	4
Specific gravity:	1.85 at 20 deg. C.
Melting point:	1,284 deg. C.
Crystal structure:	Hexagonal close packed $\frac{c}{a} = 1.585$
Lattice constants:	a = 2.28 A; c = 3.58 A
Goldschmidt's atomic diameter for coordination No. 12:	2.25A
Electric conductivity (20 deg. C.):	40 per cent that of copper
Thermal conductivity (20 deg. C.):	0.385 cal./cm.²/deg. C./sec. (42 per cent of copper)
Specific heat:	0.425 cal./gm./deg. C. at 20 deg. C (4.6 times copper)
Linear coefficient of expansion (20-100 deg. C.):	12.3×10^{-6} per deg. C.
Linear coefficient of expansion (20-700 deg. C.):	17.8×10^{-6} per deg. C.
Vapor pressure:	0.001 mm. Hg at 1,400 deg. C.; 760 mm. Hg at 3,000 deg. C.
Tensile strength:	30,000 lbs. per sq. in.
Elongation (20 deg. C.):	Zero
Hardness:	As low as 60 Brinell has been reported [4]
Young's modulus:	40,000,000 lbs. per sq. in.

unusual compounds may be formed. This viewpoint finds some support in the research reported by W. Kroll[5] who sought to obtain pure beryllium by distilling a powdered mixture of beryllium oxide and titanium in vacuum at 1,800 deg. C.

Inspection of the titanium-treated beryllium showed that there were no oxide films in the lower portions of the poured ingot, but that the upper part of the ingot sometimes contained oxide films perhaps sucked from the surface, and its upper surface was coated with a very thin film of oxide. Presumably the reaction of titanium with beryllium occurs principally within the liquid alloy to reduce the entrapped oxide films to metal. The oxide reaction products have no harmful effect on the hot working of the beryllium. Whether high temperatures or long times will cause complete disappearance of BeO from the melt is not known but is expected.

In the solid alloy titanium appears as a beryllium-titanium compound, Fig. 2, which lowers the melting point of beryllium slightly through eutectic formation. Some titanium also may be in solid solution. Since not all of the titanium disappears as oxide, it is believed that the excess represents metal that either has not had time to react with BeO at the casting temperature, or is in equilibrium with the oxide content of the melt. The microstructure of the ingots suggests that the eutectic of titanium and beryllium lies between ½ per cent and 2 per cent Ti. An alloy containing ⅛ per cent Ti was 65 Rockwell B. With 2 per cent Ti the hardness rose to 80. So far as is known titanium in the amounts referred to has scarcely any effect on the other properties of beryllium.

Zirconium in about the same percentages as titanium may be used instead of titanium and has the same effect on hot rolling and microstructure. When zirconium was melted with beryllium, no exothermic reaction was observed. To assure complete solution of the zirconium, the melt was heated to 1,500 deg. C.

Attempts have been made to alloy beryllium with several other elements. Molybdenum, tungsten, nickel, and iron alloy readily with beryllium but increase the hardness and brittleness. Aluminum, even in small percentages, lowers the melting point of beryllium too greatly to be advantageous. Silver, as Sloman[4] showed, also lowers the melting point; vacuum melted silver containing 2 per cent Be did not hot roll satisfactorily. An unsuccessful attempt was made to alloy lithium with beryllium in vacuum by pouring molten beryllium into a beryllium oxide mold containing lithium. It appeared that every trace of lithium was lost by volatilization, which was explosive in character.

Carbon also is difficult to alloy with beryllium although, as stated above, excessive temperature sets off the carbide reaction between melt and crucible. The reaction may convert part or all of the melt to a brown mass of carbide which seems to have little, if any, solubility in liquid beryllium. Melts in beryllium oxide crucibles, to which several per cent of carbon was added as blocks or powder, contained a little graphite and part of the carbon had been converted to carbide. The resulting ingots resembled unalloyed beryllium in hot rolling.

Hot Working

The malleable beryllium-titanium alloys have been rolled in air at 600 to 900 deg. C. from ⅛ in. thick to a thickness of 1/32 in., using about 20 passes and an oxy-gas torch. To avoid the oxidation that occurs in air the beryllium has been rolled in an envelope of nickel or stainless steel sheets. The beryllium rolls equally well whether cut longitudinally or transversely from the ingot, and the grain size of the ingot has little, if any, effect. Cupping is possible using heated punches and dies. Samples of hot rolled and cupped beryllium are illustrated in Fig. 4. Despite hot rolling, the surface of the flexible sheet 0.004 in. thick is remarkably smooth. Little of the edge cracking that frustrated the attempts of earlier investigators was observed.

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[4] H. A. Sloman. "Researches on Beryllium," *J. Inst. Metals*, Vol. 49, 1932, pages 365-388.

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EDITORIAL

(Continued from page 575)

their first-hand knowledge of potential resources — have had an almost instinctive feeling of invulnerability in view of our generally vast raw-material resources, tremendous productive capacity *vis-à-vis* the Axis and unequalled technological efficiency; time, the feeling has been, is on our side to such an extent that we have only to get in production and ultimately we can overwhelm our enemies with towering waves of ships, black clouds of planes and endless columns of tanks.

It is now clear, however, that time has been on the enemy's side — the time that he used in the past 10 years to build his war machines — and that our vulnerability is actually so great right now that thinking only in terms of *future* victories (*i.e.* 2 or 3 yrs. from now) is a colossal and potentially tragic delusion.

Our immense metal resources and metallurgical engineering productive capacity will be of absolutely no use to us in 1944's hypothetical battles if the enemy has destroyed us in 1942 or 1943. The time to produce is *now*. Metallurgical engineers must speed up *today's* production, and design for delivery in April, May and June, rather than next year. Metal-industries executives must build, finance and convert with the spring of 1942 crowding every other time-period out of their minds.

We must all work as if our very lives depended on it—as indeed they do!

—F.P.P.

Silver in Industry

The periodical statements from the American Silver Producers' Research Project, under the direction of Handy & Harman, focus interest on the growing industrial importance of silver. Fortunately, of all the metals, we have silver in relative abundance. It has not so far been affected by priorities or allocations.

Indicative of its expanding industrial use, there were used last year in the United States and Canada, a new peak of 80,000,000 ounces —an increase of 95 per cent over 1940. Since the Canadian consumption is placed at not over 5 per cent of the total, our use is outstanding.

As a result of an intensified research program and also because many other metals have been absorbed by the Defense and War Programs, new uses have been found for silver. The chief industrial use today is in high melting "silver solder," but a coming use is in lower melting, lead-silver, solders displacing tin. A lead-silver solder containing 2.5 per cent silver costs less than the lead-tin in which the tin content is above 25 per cent. "Intermediate" solders, carrying 1½ to 2½ per cent Ag and 10 to 20 per cent Sn, whose working properties and corrosion resistance appear more like those of lead-tin solders will probably be a first step, while industry is getting better acquainted with the completely tin-less solders.

Silver-lined bearings are now finding efficient use in aircraft engines of both the air-cooled and liquid-cooled type. The linings or coatings are electroplated. It is claimed that silver bearings will carry a higher load than copper-lead and are easier to make of uniform quality.

Because silver is such an excellent conductor of electricity, its use in bus bars instead of copper has been suggested, as a way of storing silver while making use of it.

Silver often suffers because it is ranked as a "precious" metal. Actually, the price of industrial silver is $5.10 per avoirdupois pound. Molybdenum, tungsten, or beryllium, which engineers and designers do not hesitate to use, cost more per pound. There is plenty of silver in the markets and it can take the place of copper, nickel and tin in certain cases. Since the metal is available to manufacturers for research and development, other new uses undoubtedly will be found. Silver and its alloys are a potent factor in our War Program and will become increasingly so.

If only half as much could be said for gold, that other metal in plentiful supply!—E.F.C.

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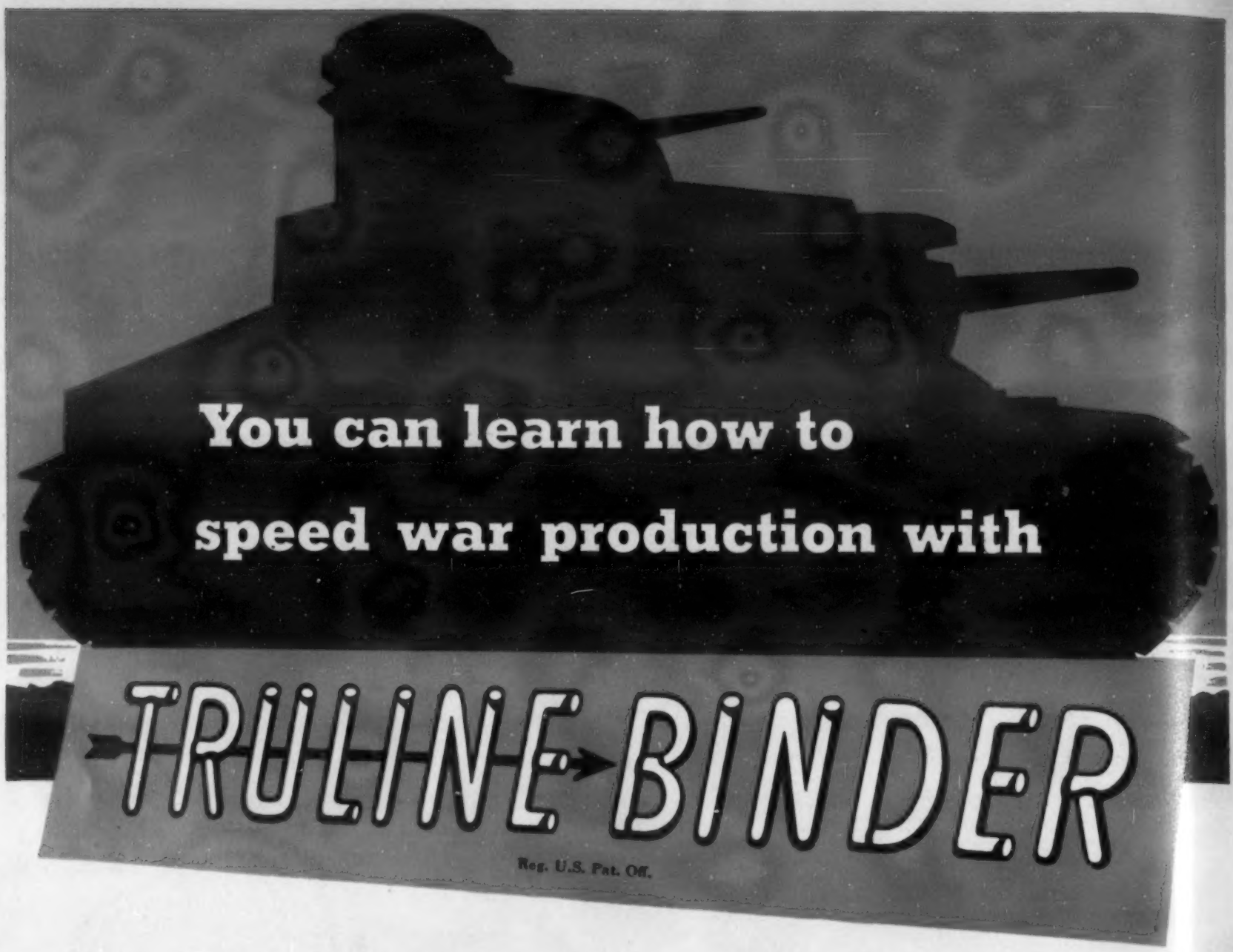

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Preview of the

Annual Conclave of American Foundrymen

Introduction

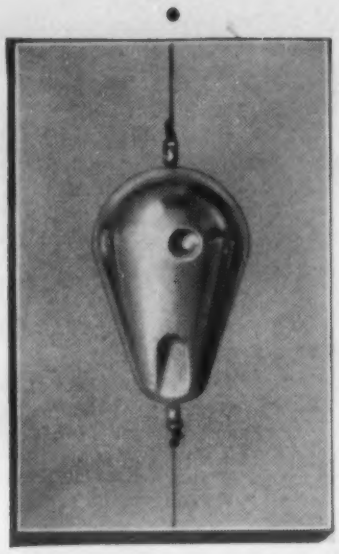
The American Foundrymen's Association will hold its 46th annual convention in Cleveland this year, April 20 to 24. In conjunction with this the biennial exhibition—The Foundry and Allied Industries Show—will be a feature. Both the convention and show are to be housed in the Public Auditorium. Due to the war and the role which foundry operations are playing in war equipment, this year's affair has been designated the Western Hemisphere Foundry Congress.

A technical program (presented on other pages in tentative form) has been prepared which is outstanding and a great value to the foundry industry in its war production efforts. There are 47 sessions scheduled, including papers, lectures and addresses by leading foundry authorities on ferrous and nonferrous metallurgy, research, shop practice, management and training. A special feature will be a session devoted to papers on foundry practice in Central and South America, preceded by a reception to guests from Latin American countries and their consuls and official representatives in this country.

The exhibition, or Foundry and Allied Industries Show, will include displays by companies whose chief purpose in exhibiting is to help the industry reach a full wartime basis as quickly and efficiently as possible. Both the WPB and the OPA will set up offices in the exhibit halls where answers to urgent questions of priorities, contracts and castings prices can be obtained.

Under the auspices of the Cleveland Post of the Army Ordnance Association, extensive exhibits of ordnance matériel will be presented in Lakeside Hall. These will include displays of military and naval equipment suitable for foundry production.

The annual banquet will be held Thursday evening. At this function several awards to prominent foundrymen will be formally presented.



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Tentative Technical Program

A large number of sessions, 47 in all, have been arranged for the 46th annual convention of the A. F. A. These include not only the technical papers on various subjects pertinent to all branches of the foundry industry, but also lectures, addresses and important discussions at round-table and other luncheons.

A feature of the technical feast is a session devoted to foundry practice in Central and South America. It is scheduled for Monday evening, April 20; speakers from Mexico and Brazil are to deliver papers. A symposium on graphitization of malleable iron will be held on Tuesday, April 21. The usual sand and gray iron shop courses are continued.

The tentative program follows:

Monday, April 20

Morning

OPENING MEETING—at 11:00

Chairman: President H. S. Simpson
Vice-Chairman: D. P. Forbes

Opening of Congress by President Simpson
Address of Welcome
Special Speaker

Afternoon

NON-FERROUS SESSION—at 2:30

Chairman: M. V. Healey, General Electric Co., Schenectady, N. Y.
Co-Chairman: D. Frank O'Connor, Watts Regulator Co., Lawrence, Mass.

"Plaster Molds for Precision Non-Ferrous Castings," by Henry Hagemeyer, Castings Patent Corp., Chicago.

"Tentative Recommended Practices for Tin Bronzes"—Committee Report.

MALLEABLE SESSION—at 2:30

Chairman: C. F. Joseph, Saginaw Malleable Iron Div., General Motors Corp., Saginaw, Mich.
Co-Chairman: R. J. Anderson, Belle City Malleable Iron Co., Racine, Wis.

"Malleable Iron Gating and Risering," by Fred Reeves, Saginaw Malleable Iron Div., General Motors Corp., Saginaw, Mich.

"Sand Control in a Mechanized Malleable Foundry," by D. F. Sawtelle, Malleable Iron Fittings Co., Branford, Conn.

"Studies on Malleabilization and Physical Properties of Some Copper Containing Malleable Irons," by C. H. Lorig and A. R. Elsea, Battelle Memorial Institute, Columbus, Ohio.

CORE PRACTICE-LECTURE COURSE—at 4:30

Chairman: E. C. Zirzow, National Malleable & Steel Castings Co., Cleveland.
Lecturer—H. W. Dietert, Harry W. Dietert Co., Detroit.

Reception to Guests from Central and South American Countries—at 5:30.

Evening

WESTERN HEMISPHERE FOUNDRY CONFERENCE—at 8:00

Presiding—Harold J. Roast, Canadian Bronze Co., Ltd., Montreal.
Co-Chairman: J. S. Vanick, International Nickel Co., New York.

"Brass Founding in Mexico," by H. H. Miller, Fundicion de Bronce Miller, Terreon, Coah, Mexico.

"Some Aspects of the Gray Iron Founding Practice in Brazil," by Miguel Siegel, Instituto de Pesquisas Technologicas, Sao Paulo, Brazil.

"Brazilian Foundry Industry," by H. A. Hunnicutt, Industrias Chimicas Brasileiras, Sao Paulo, Brazil.

"Designing for Foundry Production," by Dr. Ernest Geiger, Sao Paulo, Brazil.

PATTERNMAKING SESSION—at 8:00

Chairman: Frank Cech, Cleveland Trade School, Cleveland.
Co-Chairman: V. J. Sedlon, Master Pattern Co., Cleveland.

"Design of Core Boxes and Driers for Core Blowing," by O. A. Van Sickle, City Pattern Works, Detroit.

"Equipment for Blowing Cores," by R. F. Lincoln, Osborn Mfg. Co., Cleveland.

"Production of Copper Patterns by Electro Forming," by A. K. Laukel, Electro-Chemical Pattern & Mfg. Co., Detroit.

Tuesday, April 21

Morning

SAND SHOP COURSE (Session 1) —at 9:00

Chairman: D. F. Sawtelle, Malleable Iron Fittings Co., Branford, Conn.

"Fundamentals of Sand Control," by W. G. Reichert, American Brake Shoe & Foundry Co., Mahwah, N. J.

GRAY IRON SHOP COURSE (Session 1)—at 9:00

Chairman: W. S. Linnell, Wisconsin Steel Co., Chicago.

"Practical Theory of Shrinkage."—Discussion Leader—George Timmons, Climax Molybdenum Co., Detroit.

MALLEABLE SESSION—at 10:00

Symposium on Graphitization (Section 1)

Chairman: Dr. H. A. Schwartz, National Malleable & Steel Castings Co., Cleveland.
Co-Chairman: D. P. Forbes, Gunite Foundries, Inc., Rockford, Ill.

"Principles of Graphitization," by Dr. H. A. Schwartz, National Malleable & Steel Castings Co., Cleveland.

"The Suppression of Primary Graphite," by C. H. Junge, National Malleable & Steel Castings Co., Cleveland.

"Some Effects of Hydrogen on the Time of Malleabilization," by C. H.

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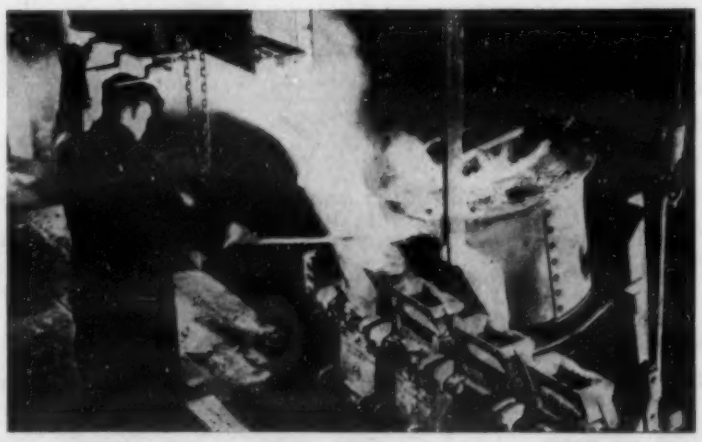

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field—less than 1%—with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

Do you have your copy of "AJAX-METELECTRIC PROGRESS" — the magazine of induction melting, electric heat treating, non-ferrous ingot and alloys? Write to: AJAX ELECTRIC FURNACE CORP., 1108 Frankford Avenue, Philadelphia, Pa.

* HUNDREDS OF MILLIONS OF POUNDS ANNUALLY

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ASSOCIATE COMPANIES: AJAX METAL COMPANY, Non-Ferrous Ingot Metal for Foundry Use
AJAX ELECTROTHERMIC CORPORATION, Ajax-Northrup Induction Furnaces for Melting, Heat-Treating
AJAX ELECTRIC COMPANY, INC., Electric Salt Bath Furnaces

Lorig and M. L. Samuels, Battelle Memorial Institute, Columbus, Ohio.

"Temperature Control of Graphitizing Furnaces," by J. H. Lansing, Malleable Founders' Society, Cleveland.

"Atmosphere Control in Annealing Furnaces," by R. J. Cowan, Surface Combustion Corp., Toledo, Ohio.

(Symposium concluded at afternoon session.)

NON-FERROUS SESSION—at 10:00

Chairman: W. J. Laird, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Co-Chairman: Wm. Romanoff, H. Kramer & Co., Chicago.

"Effect of Furnace Atmospheres on Heat Treating of Magnesium and Aluminum Alloys," by D. V. Ludwig, Capitol Foundry Corp., Long Island City, N. Y., and Wayne Martin, Sperry Gyroscope Co., New York.

"Salvage of Aluminum Alloys by Welding," by A. T. Ruppe, Bendix Products Div., Bendix Aviation Corp., South Bend, Ind.

Annual Business Meeting of Non-Ferrous Division, A.F.A.

APPRENTICE TRAINING SESSION —at 10:00

Chairman: Jas. G. Goldie, Cleveland Trade School, Cleveland.
Co-Chairman: Dean C. J. Freund, University of Detroit, Detroit.

"Foundry Apprenticeship Now, How and Why," by Donald F. Lane, Bethlehem Steel Co., Sparrows Point, Md.

Foundry Defense Training Question Box.—Discussion Leader—O. F. Carpenter, associate district representative, Training Within Industry, Detroit.

SPECIAL WAR PRODUCTION SESSION—at 11:45

Chairman: Fred J. Walls, International Nickel Co., Detroit.

(Speaker to be announced)

ROUND-TABLE LUNCHEON—NON-FERROUS DIVISION—at 12:30

Chairman: B. A. Miller, Cramp Brass & Iron Foundries, Div., Baldwin Locomotive Works, Philadelphia.
Co-Chairman: C. O. Thieme, H. Kramer & Co., Chicago.

Discussion Topics and Leaders:

"Some Causes of Porosity in Silicon Bronze Castings," by J. E. Crown, U. S. Naval Gun Factory, Washington.

"Some Causes of Porosity in Navy

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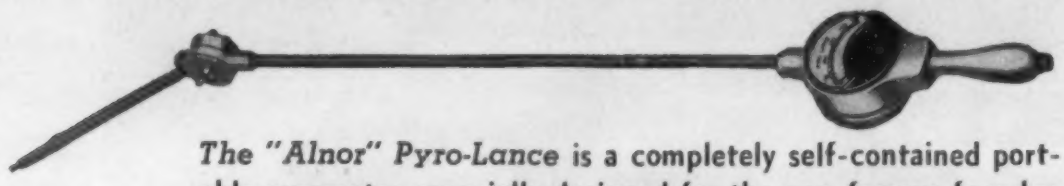

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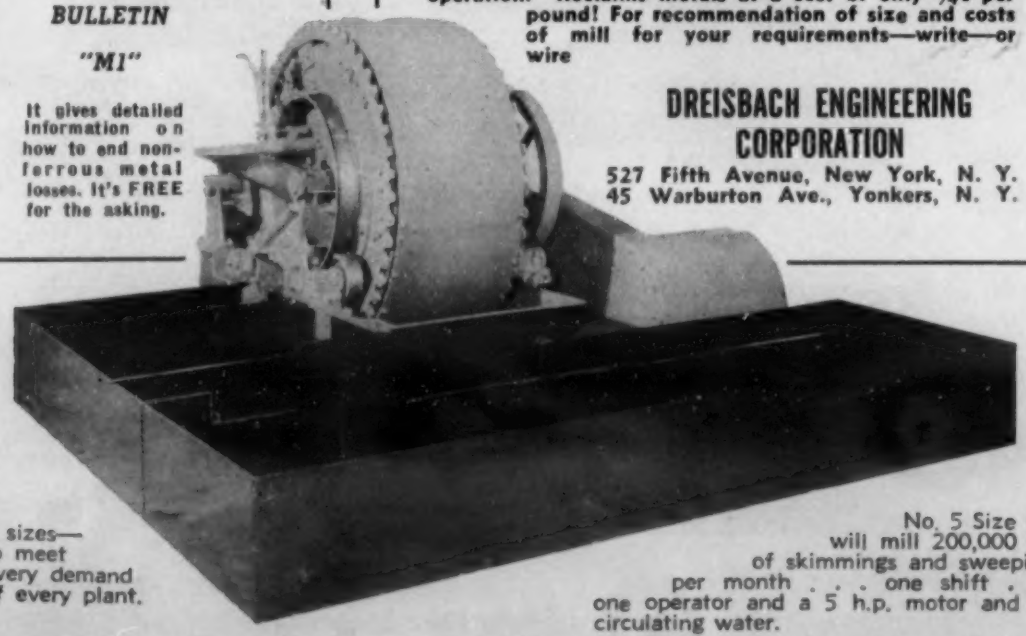

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LUNCHEON—MALLEABLE DIVISION—at 12:30

Afternoon

MALLEABLE SESSION—at 2:30

Symposium on Graphitization (Section 2)

Chairman: Dr. H. A. Schwartz, National Malleable & Steel Castings Co., Cleveland.

Co-Chairman: Carl Joseph, Saginaw Malleable Iron Div., General Motors Corp., Saginaw, Mich.

"Intermittent Annealing Furnaces," by W. R. Bean and W. R. Jaeschke, Whiting Corp., Harvey, Ill.

"Electric Furnace Annealing," by R. M. Cherry, General Electric Co., Schenectady, N. Y.

"Tunnel Kiln Annealing," by R. J. Anderson, Belle City Malleable Iron Co., Racine, Wis.

"The Promotion of Annealing Rate by the Selection of Chemical Composition," by W. D. McMillan, International Harvester Co., Chicago.

"Arrested Anneal Malleables," by D. P. Forbes, Gunite Foundries Corp., Rockford, Ill.

PATTERNMAKING SESSION—at 2:30

Chairman: E. J. Brady, Western Foundry Co., Chicago.

Co-Chairman: A. Pyle, Jr., Pyle Pattern & Mfg. Co., Muskegon, Mich.

"Plastic Coatings for Core Boxes and Patterns"—Report of Investigation by George Dreher, Ampco Metal Inc., Milwaukee.

"Discussion of Rubber Coatings for Core Boxes," by J. E. Crown, U. S. Naval Gun Factory, Washington.

"Specifications for Foundry and Pattern Lumber," by E. T. Kindt, Kindt-Collins Co., Cleveland.

"Driers and Green Topping Cores," by George Gedeon, Aluminum Co. of America, and Frank C. Cech, Cleveland Trade School, Cleveland.

CORE PRACTICE-LECTURE COURSE—at 4:30

Chairman: L. P. Robinson, Werner G. Smith Co., Cleveland.

Lecturer—H. W. Dietert, Harry W. Dietert Co., Detroit.

Evening

ANNUAL APPRENTICE INSTRUCTORS' DINNER—at 6:30

Presiding—James G. Goldie, Cleveland Trade School, Cleveland.

EVERDUR INGOTS

This copper-silicon alloy possesses many of the desirable properties of the tin bronzes.

The nominal composition of Everdur Ingots is Copper, 94.90; Silicon, 4.00; Manganese, 1.10. This composition will meet the requirements of recognized standards such as Navy Specification 46B28 and Federal Specification QQ-C-593.

Everdur standard test coupons cast in green sand will have these approximate physical properties:

Tensile Strength . .	50,000 p.s.i.
Yield Strength* . .	20,000 p.s.i.
Elongation	25% in 2″
Reduction in Area .	25%
Brinell No.	80
(10 mm. ball, 500 Kg. load)	

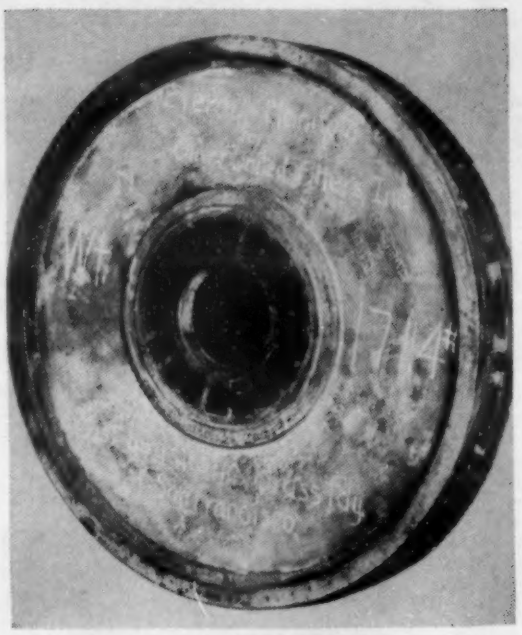
*At 0.50% elongation under load

General Properties

Melting Point . .	1832°F. (1000°C.)
Specific Gravity	8.23
Weight	0.297 lb. per cu. in.
Pattern Maker's Shrinkage	3/16″ per ft.

Sound, strong small-section Everdur Castings

Everdur has been successfully used over a 15-year period for the production of strong, sound castings. It is furnished ready for use in 25-pound notched ingots and can be melted and cast by regular brass and bronze foundry equipment.



Cast Everdur manifold. Weight 1,714 lbs.

Foundry Practice

Anaconda Publication E-1, offered free, presents a *detailed* discussion of foundry practice with Everdur.

Contents of this publication include suggestions for composition and control of the charge; types of furnaces for melting; fluxing and melting procedure; practices in molding, types of sand, core construction, pattern making, gating, etc. Pouring data are presented, as well as detailed instructions for the cleaning and finishing, machining, welding and heat treating of Everdur castings.

Summary

Everdur copper-silicon alloy for casting purposes is a high-strength material, relatively inexpensive but possessing many of the desirable properties usually associated with higher-priced metals.

Everdur offers outstanding resistance to a large number of normally corrosive solutions and atmospheres. Obviously, it is not equally resistant to all. Information regarding the corrosion resistance of Everdur under specific conditions may be obtained from the Technical Department of The American Brass Company. This service is available without cost.

Anaconda Publication E-1, 6th Edition, contains detailed information on general properties, charging, melting, molding, pouring, etc., of Everdur Metal. Write for a copy. 41153A

Everdur Metal

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NON-FERROUS DIVISION DINNER—at 6:30

Presiding—Wm. J. Laird, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

FOREMAN TRAINING GROUP, DINNER AND DISCUSSION—at 6:30

Chairman: W. E. George, Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich.

"Why Foremanship Training," by V. J. Swanson, Tractor Works, International Harvester Co., Chicago.

"Teaching Foremen to Teach," by W. E. Odom, Wm. Odom Associates, Chicago.

REFRACTORIES FOR FOUNDRY USE—at 8:00

Chairman: J. A. Bowers, American Cast Iron Pipe Co., Birmingham, Ala.
Co-Chairman: Charles Reed, Jr., Retort & Fire Brick Co., Chicago, and R. E. Wilke, Deere & Co., Moline, Ill.

"Natural Stone as a Cupola Refractory," by J. A. Bowers, American Cast Iron Pipe Co., Birmingham, Ala.

"Monolithic Cupola Linings," by R. A. Clark, Lakey Foundry & Machine Co., Muskegon, Mich.

"Patching in the Cupola," by C. S. Reed, Jr., Chicago Retort & Fire Brick Co., Chicago.

Wednesday, April 22

Morning

SAND SHOP COURSE (Session 2) —at 9:00

Chairman: C. P. Randall, Eastern Clay Products Co., Eifort, Ohio.

"Practical Fundamentals of Sand Shop Control," by W. G. Reichert, American Brake Shoe & Foundry Co., Mahwah, N. J.

GRAY IRON SHOP COURSE (Session 2)—at 9:00

Chairman: R. F. Hine, Studebaker Corp., South Bend, Ind.

"Shrinkage in Automotive Castings"—Discussion Leader (to be announced).

ANNUAL BUSINESS MEETING AND AWARDS LECTURE—at 10:00

Address of President Simpson
Reports of Officers
Awards Presentation
Awards Lecture

PLANT DEFENSE AND PROTECTION—at 2:30

Report of Committee on Plant Protection During War Times, by James R. Allan, International Harvester Co., Chicago.

GRAY IRON SESSION—at 2:30

Chairman: Max Kuniansky, Lynchburg Foundry Co., Lynchburg, Va.
Co-Chairman: John Lowe, Battelle Memorial Institute, Columbus, O.

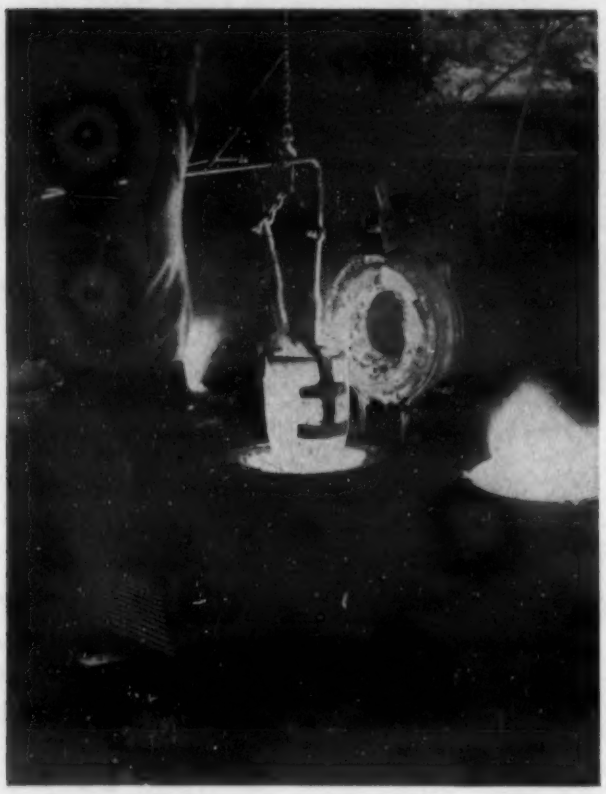
"Temperature Measurement of Molten Cast Iron With the 'Rayotube' and Optical Pyrometer," by R. H. Koch and Dr. A. E. Schuh, U. S. Pipe & Foundry Co., Burlington, N. J.

"Cupola Control," by Fulton Holtby and H. F. Scobie, University of Minnesota, Minneapolis, Minn.

"Direct Determination of Combined Carbon in Cast Iron and Steel," by J. G. Donaldson, Battelle Memorial Institute, Columbus, Ohio. (Presented by title.)

STEEL SESSION—at 2:30

Chairman: F. A. Melmoth, Detroit Steel Casting Co., Detroit.



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1. Unpack carefully.
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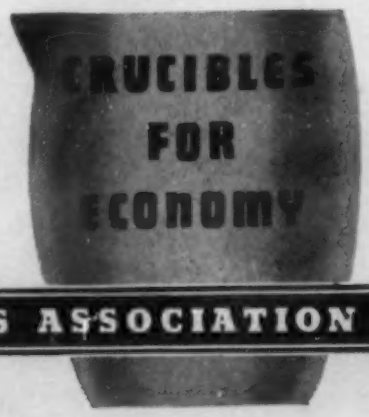
3. For the first heat follow the instructions of the manufacturer of the particular type of crucible you are using.
4. Charge ingots or long pieces so they will not wedge and rupture the crucible when expanding.
5. Empty the crucible on the last heat of the day.
6. Be careful in the use of stirrers or pokers for coke fires.
7. If you use coke fires avoid pinching coke between tong blades and crucible: scrape coke from bottom of crucible before setting down in shanks.
8. If oil or gas are used keep proper ratio of fuel and air; the flame should be neutral or only slightly oxidizing or reducing.

FOR COMPLETE AND DETAILED INSTRUCTIONS WRITE FOR BOOKLET TO THE ADDRESS BELOW



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Co-Chairman: K. V. Wheeler, American Steel Castings Co., Newark, N. J.

"Grinding Wheel Cost Control," by Jeff. Alan Westover, Dyer Engineers, Inc., Buffalo, N. Y.

"Atmospheric Pressure and the Steel Casting—A New Technique of Gating and Risering," by H. F. Taylor and E. A. Rominski, Naval Research Laboratories, Washington.

"Studies of Center-line Shrinkage," by J. A. Duma and S. W. Brinson, Norfolk Navy Yard, Portsmouth, Va.

CHAPTER DELEGATE CONFERENCE—at 3:00

CORE PRACTICE—LECTURE COURSE—at 4:30

Chairman: J. B. Caine, Sawbrook Steel Casting Co., Lockland, Ohio.

Lecturer: H. W. Dietert, Harry W. Dietert Co., Detroit.

Evening

CHAPTER OFFICERS' DINNER—at 6:30

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ANNUAL ENGINEERING FOUNDRY INSTRUCTORS' DINNER—at 6:30

JOB EVALUATION AND TIME STUDY SESSION—at 8:00

Chairman: F. E. Wartgow, American Steel Foundries, East Chicago, Ind.
Co-Chairman: J. A. Westover, Dyer Engineers, Inc., Cleveland.

"The Use of Job Evaluation in the Application of Time Study," by E. L. Berry and E. A. Berg, Link Belt Co., Chicago.

THE FOUNDRY INDUSTRY AND ENGINEERING TRAINING SESSION—at 8:00

Chairman: F. G. Sefing, International Nickel Co., New York City.
Co-Chairman: A. C. Davis, Cornell University, Ithaca, N. Y.

"Report of Survey of Foundry Instruction," by A.F.A. Committee on Cooperation with Engineering Schools.

"Engineering Graduates in the Foundry," by S. D. Moxley, American Cast Iron Pipe Co., Birmingham, Ala.

"The College Student Views the Foundry Industry," by C. J. Freund, Dean of Engineering, University of Detroit, Detroit.

SAND RESEARCH SESSION—at 8:00

Chairman: L. B. Knight, Jr., National Engineering Co., Chicago.
Co-Chairman: F. L. Weaver, Great Lakes Foundry Sand Co., Detroit.

"Investigation of Durability of Foundry Sands," by J. CoVan, University of Illinois, Urbana, Ill.

"Investigation of Foundry Sands Durability," by A. S. Nichols, Illinois Clay Products Co., Chicago.

"Causes of Drying Out of Synthetic Sands," by N. J. Dunbeck, Eastern Clay Products Co., Eifort, Ohio.

STEEL SESSION—at 8:00

Chairman: L. C. Wilson, Reading Steel Casting Div., American Chain and Cable Co., Inc., Reading, Pa.

"Steel Pouring Refractories," by R. H. Stone, Vesuvius Crucible Co., Swissvale, Pa.

"Use of Iron Oxides in Cores for Steel Castings," by F. B. Riggan, Key Co., E. St. Louis, Ill.

Report of Committee on Radiography.

Thursday, April 23

Morning

GRAY IRON SHOP COURSE

FOUNDRYMEN OF AMERICA ATTENTION!

REPLACE TIN CONTENT BRONZES WITH

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COPPER SILICON ALLOY

INGOTS FOR SAND CASTINGS

HERCULOY SUPERIORITY:

HERCULOY is not an emergency product! In use for many years, it enjoys widespread acceptance for general foundry castings, such as valves, valve bodies, flanges, fittings, pumps, electrical equipment, marine hardware, etc.

HERCULOY is a complete alloy ingot! Merely melt and cast. Deoxidizers or hardening agents unnecessary. The metal possesses excellent fluidity. Castings are sharp in detail. Minimum of surface finishing required. Welds satisfactorily. Non-magnetic.

HERCULOY makes good pressure castings! Foundry tests indicate that this alloy has withstood hydraulic pressures well over 1000 p.s.i.

PROPERTIES: nominal composition of Herculoy is Copper, 92; Tin, .25; Silicon, 3.5; Zinc, 4.5. Conforms to Gov. Spec. 46B28 and QQ-C-593. Physical properties are equal or superior to most tin bronzes. Tensile strength is approximately 50,000 p.s.i., and Elongation 40%. Melting Point—1875°F.; Specific Gravity—8.54; Weight—.308 lb. per cu. in; Pattern Makers Shrinkage—3/16" per ft.

For additional information and complete technical data, contact our nearest sales office.

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SEATTLE, WASH.
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(Chicago District)

(Session 3)—at 9:00

Chairman: H. H. Wilder, Detroit Stoker Co., Monroe, Mich.

"Shrinkage in Pressure Castings." —Discussion Leader—H. H. Judson, Gould Pumps, Inc., Seneca Falls, N. Y.

SAND SHOP COURSE
(Session 3)—at 9:00

Chairman: E. E. Woodliff, Harry W. Dietert Co., Detroit.

"Practical Fundamentals of Sand Control," by W. G. Reichert, American Brake Shoe & Foundry Co., Mahwah, N. J.

SAND RESEARCH SESSION—at 10:00

Chairman: Dr. H. Ries, Ithaca, N. Y.
Co-Chairman: H. A. Deane, Brake Shoe & Castings Div., American Brake Shoe & Foundry Co., New York City.

"Dry Sand Molding Procedure for Heavy Castings," by W. A. Hambley and A. Lebesh, Allis-Chalmers Mfg. Co., Milwaukee.

"Sea Coal in Foundry Sands," by E. C. Zirzow, National Malleable & Steel Castings Co., Cleveland.

Report of Committee on Sintering Sands.

FOUNDRY COSTS—at 10:00

Chairman: R. L. Lee, Liberty Foundry Div., Grede Foundries, Inc., Wauwatosa, Wis.

Round Table Discussion on Current Cost Methods Problems.

CUPOLA RESEARCH PROJECT SESSION—at 10:00

Chairman: D. J. Reese, International Nickel Co., New York City.

Reports of Sub-Committees of Cupola Research Project.

SPECIAL WAR PRODUCTION SESSION—at 11:45

Chairman: Dean C. J. Freund, University of Detroit, Detroit.

"Training Methods for War Production," by Wm. F. Patterson, Federal Committee on Apprenticeship, Washington.

ROUND-TABLE LUNCHEON—STEEL DIVISION—at 12:30

Afternoon

GRAY IRON SESSION—at 2:30

Chairman: S. C. Massari, Association of Manufacturers of Chilled Car Wheels, Chicago.
Co-Chairman: R. G. McElwee, Alloy Div., Vanadian Corp. of America, Detroit, Mich.

"Oxidation Resistance of Ordinary and Graphitized Cast Irons," by C. O. Burgess and A. E. Schrubsall, Union Carbide & Carbon Research Laboratories, Niagara Falls, N. Y.

"Cast Iron—Strength vs. Structure," by R. R. Adams, Battelle Memorial Institute, Columbus, Ohio.

"Metallurgical Study of Cast Iron for Glass Forming Molds," by W. H. Bruckner, University of Illinois, Urbana, Ill., and H. Czyzewski, Caterpillar Tractor Co., Peoria, Ill.

PLANT AND PLANT EQUIPMENT—at 2:30

Chairman: James Thomson, Continental Roll & Steel Foundry Co., East Chicago, Ind.
Co-Chairman: W. R. Jennings, John Deere Tractor Co., Waterloo, Iowa; E. W. Beach, Campbell Wyant & Cannon Foundry Co., Muskegon, Mich.

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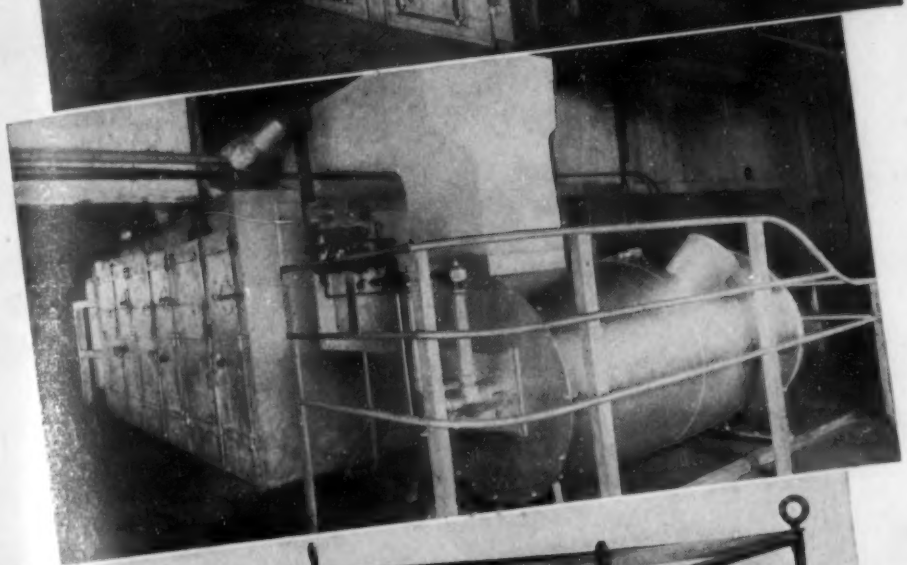

AIRHEAT CONVERSION UNITS

• Maehler heaters and recirculating airheat systems can be installed to modernize old style brick or metal ovens. Results from many such installations have been outstanding — outputs have increased as much as 6 times, with better work.

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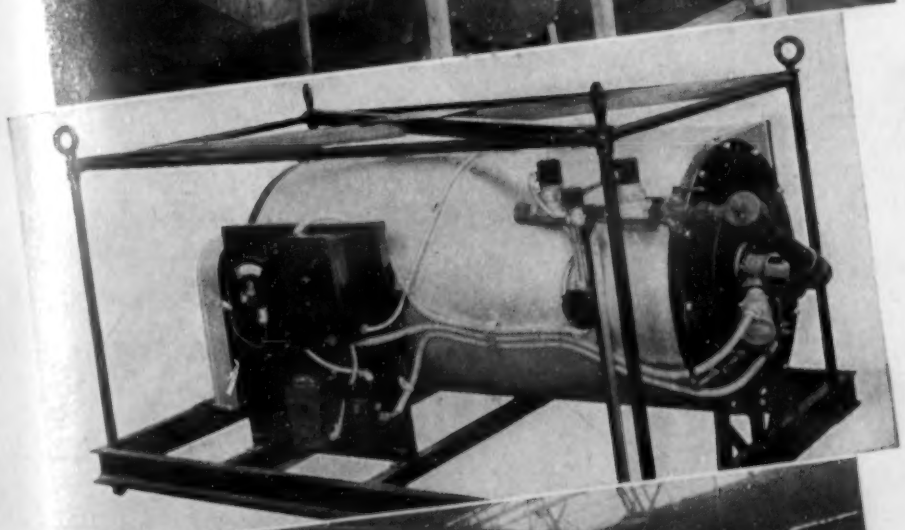

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Foundry," by H. B. Nye, New York Air Brake Co., Watertown, N. Y.

"Priorities and Foundry Equipment," by W. R. Bean, Chief, Foundry Equipment and Supplies Unit, Tools Section, War Production Board, Washington, D. C.

CORE PRACTICE—LECTURE COURSE—at 4:30

Chairman: B. D. Claffey, General Malleable Corp., Waukesha, Wis.

Lecturer—H. W. Dietert, Harry W. Dietert Co., Detroit.

Evening

ANNUAL DINNER A.F.A.—at 7:00

Friday, April 24

SAND SHOP COURSE (Session 4) —at 9:00

Chairman: E. E. Woodliff, Harry W. Dietert Co., Detroit.

"Practical Fundamentals of Sand Control," by W. G. Reichert, American Brake Shoe & Foundry Co., Mahwah, N. J.

GRAY IRON SHOP COURSE (Session 4)—at 9:00

Chairman: P. T. Bancroft, Republic Coal & Coke Co., Moline, Ill.

"Shrinkage — General Castings" — Discussion Leader—E. J. Carmody, C. C. Kawin Co., Chicago.

STEEL SESSION—at 10:00

Chairman: C. E. Sims, Battelle Memorial Institute, Columbus, Ohio.
Co-Chairman: John Howe Hall, Philadelphia.

Methods for Producing Steel for Castings.

"Acid Electric Furnace Slag Control," by John Juppenlatz, Lebanon Steel Foundry, Lebanon, Pa.

"Acid Open-Hearth Practice for Steel Castings," by G. S. Baldwin, Standard Steel Works Div., Baldwin Locomotive Works, Burnham, Pa., and C. W. Briggs, Steel Founders' Society of America, Cleveland.

"Making Navy Steel in Basic Electric Furnaces," by S. W. Brinson and F. B. Anderson, Norfolk Navy Yard, Portsmouth, Va.

"Protection of Uniform Steel for a Light Castings Foundry," by C. H. Kain and L. W. Sanders, Lake & Elliott, Braintree, Essex, England. (I.B.F. Exchange Paper.)

GRAY IRON SESSION—at 10:00

Chairman: Dr. J. T. MacKenzie, American Cast Iron Pipe Co., Birmingham, Ala.
Co-Chairman: V. A. Crosby, Climax Molybdenum Co., Detroit.

"Production Hardening of Close Grain Cast Iron," by D. V. Ludwig, Capitol Foundry Corp., Long Island City, N. Y.

"Effects of Alloys on Transformation," by R. G. McElwee, Vanadium Corp. of America, Detroit.

"Effects of Ladle Inoculation on Austenitic Cast Iron," by J. T. Eash, International Nickel Co., Bayonne, N. J.

SAND RESEARCH SESSION —at 10:00

Chairman: N. J. Dunbeck, Eastern Clay Products Co., Eifert, Ohio.
Co-Chairman: C. M. Saeger, National Bureau of Standards, Washington, D. C.

Investigation of Sand Properties at High Temperatures—Committee Report.

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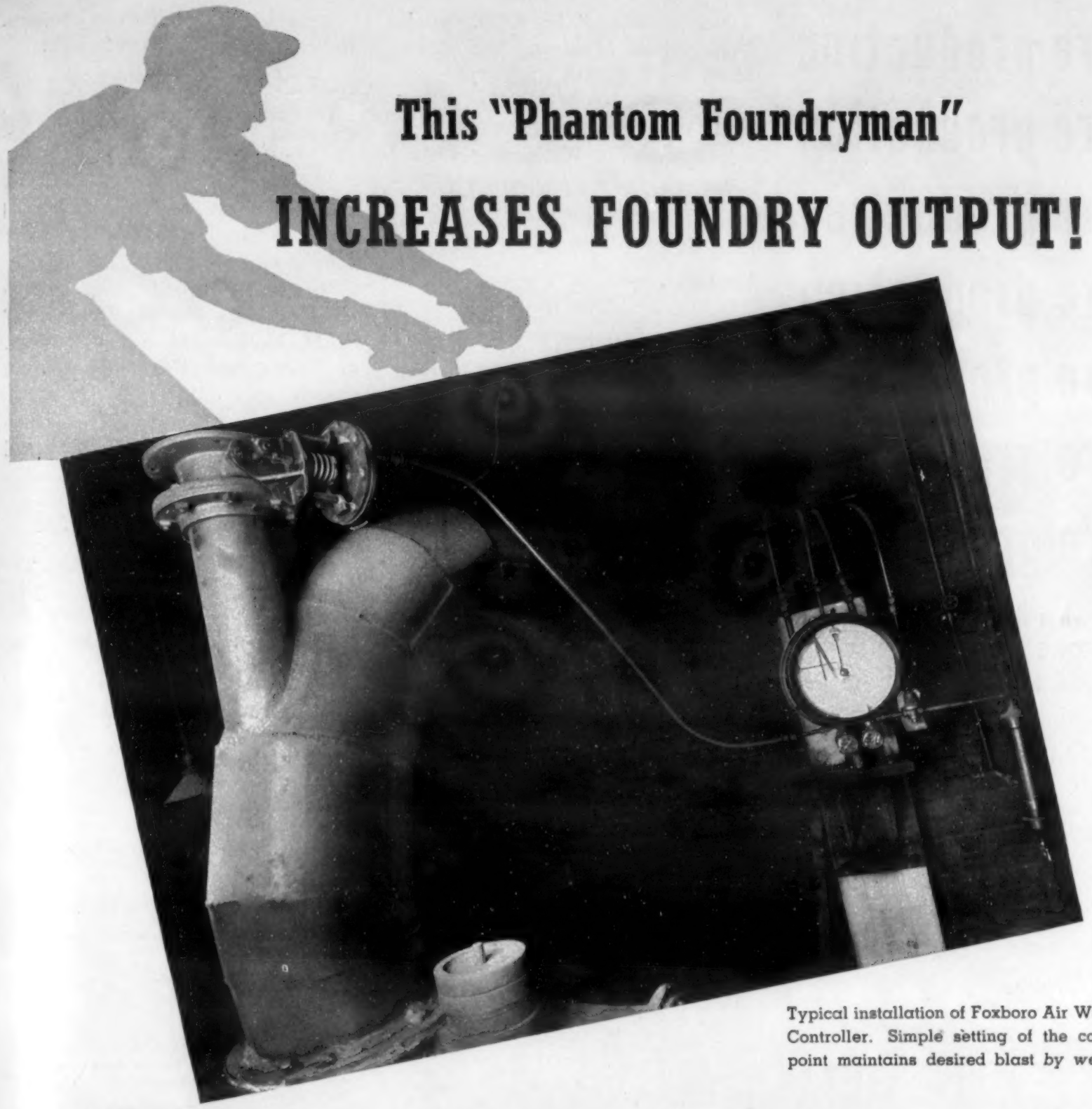

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CITY AND STATE

MAIL THIS COUPON TODAY!

Terms of Work," by E. O. Lissell, University of Michigan, Ann Arbor, Mich. and E. J. Ash.

"Resin Binders in Molding Sand," by E. Pragoff and C. P. Alvus, Hercules Powder Co., Wilmington, Del.

SPECIAL WAR PRODUCTION SESSION—at 11:45

(Speaker to be announced)

Afternoon

STEEL SESSION—at 2:00

Chairman: R. A. Gezelius, General Castings Corp., Eddystone, Pa.

Co-Chairman: Henry Phillips, Lebanon Steel Foundry, Lebanon, Pa.

"Properties of Low Alloy Copper Cast Steels," by H. F. Taylor, H. F. Bishop and E. A. Rominski, Naval Research Laboratory, Washington.

"Welding of Medium Carbon Steel Castings by Metal Arc Process," by S. E. Mueller, Falk Corp., Milwaukee, Wis.; A. B. Smith, American Bureau of Ships, Chicago, and J. F. Oesterle, University of Wisconsin, Madison, Wis.

Report of Committee on Developments in Magnetic Powder Test.

GRAY IRON SESSION—at 2:00

Chairman: Dr. A. E. Schuh, United States Pipe & Foundry Co., Burlington, N. J.

"Elastic Properties of Some Alloy Cast Irons," by A. I. Krynitsky and C. M. Saeger, Jr., National Bureau of Standards, Washington.

"Statistical Methods as an Aid to the Control of Foundry Operations," by H. H. Fairfield, Canadian Dept. of Mines and Resources, Ottawa, Canada.

"Effects of Phosphorus on Growth of Cast Iron," by Morris Cohen and M. N. Dastur, Massachusetts Institute of Technology, Cambridge, Mass.

CORE PRACTICE-LECTURE COURSE—at 4:30

Chairman: R. F. Lincoln, Osborn Mfg. Co., Cleveland, Ohio.

Lecturer—H. W. Dietert, Harry W. Dietert Co., Detroit.

List of Exhibitors

Name	Hall No.
A	
Adams Co., Dubuque, Iowa.	4
Ajax Electric Co., Inc., Philadelphia.	1
Ajax Electric Furnace Corp., Philadelphia.	1
Ajax Electrothermic Corp., Trenton, N. J.	1
Ajax Metal Co., Philadelphia.	1
Alpha-Lux Co., Inc., New York.	1
American Air Filter Co., Inc., Louisville, Ky.	4
American Crucible Co., Shelton, Conn.	1
American Fdry. Equipment Co., Mishawaka, Ind.	4
American Foundrymen's Ass'n, Chicago	2
American Metal Market, New York.	1
American Optical Co., Chicago.	1
American Society for Metals, Cleveland.	1
American Steel Abrasive Co., Galion, Ohio.	4
Apprentice Casting & Patternmaking Contest Exhibit.	4
Arcade Mfg. Co., Freeport, Ill.	4
Automatic Transportation Co., Chicago.	4
Ayers Mineral Co., Zanesville, Ohio.	1
B	
Baker-Perkins, Inc., Saginaw, Mich.	4
C. O. Bartlett & Snow Co., Cleveland.	4
Bay State Abrasive Prod. Co., Westboro, Mass.	1
Black, Sivalls & Bryson, Inc., Kansas City, Mo.	2
Blaw Knox Co., Pittsburgh, Pa.	2
Blystone Corp., Cambridge Springs, Pa.	1
Buckeye Products Co., Cincinnati.	1
Adolph I. Buehler, Chicago.	2
Business Publishers International Corp., New York.	2
C	
Campbell-Hausfeld Co., Harrison, Ohio.	4
Canadian Radium & Uranium Corp., New York.	1
Edwin S. Carman, Inc., Cleveland.	1
Certified Core Oil & Mfg. Co., Cicero, Ill.	1
Chain Belt Co., Milwaukee.	4
Champion Fdry. & Machine Co., Chicago.	4
Chicago Mfg. & Distributing Co., Chicago	1
Chicago Retort & Fire Brick Co., Chicago.	2
Clearfield Machine Co., Clearfield, Pa.	4
Cleveland Blow Pipe & Mfg. Co., Cleveland.	4
Cleveland Flux Co., Cleveland.	1
Cleveland Pneumatic Tool Co., Cleveland.	4
Cleveland Quarries Co., Cleveland.	4
Cleveland Trade School, Cleveland.	4
Climax Molybdenum Co., New York.	2
L. A. Cohn & Bro., Inc., Chicago.	2
Combined Supply & Equipment Co., Buffalo, N. Y.	2
Conco Engineering Works, Mendota, Ill.	1
Corn Products Sales Co., New York	1
Crucible Furnace Co., Charlottesville, Va.	4

Name	Hall No.
D	
Davenport Machine & Fdry Co., Davenport, Iowa.	4
Dayton Oil Co., Dayton, Ohio.	1
Delhi Foundry Sand Co. Cincinnati, Ohio.	1
Delta Oil Products Co., Milwaukee, Wis.	2
Wm. Demmler & Bros., Kewanee, Ill.	4
Despatch Oven Co., Minneapolis.	4
Detroit Electric Furnace Div., Kuhlman Electric Co., Bay City, Mich.	2
DeWalt Products Corp., Lancaster, Pa.	4
Harry W. Dietert Co., Detroit.	2
Jos. Dixon Crucible Co., Jersey City, N. J.	1
Dodge Mfg. Corp., Mishawaka, Ind.	1
Dougherty Lumber Co., Cleveland.	4
Duquesne Smelting Corp., Pittsburgh.	1
E	
Eastern Clay Products, Inc., Eifort, Ohio	1
Electro Refractories & Alloys Corp., Buffalo, N. Y.	4
Elwell-Parker Electric Co., Cleveland.	4
Eutectic Welding Alloys, Inc., New York	3
F	
Fanner Mfg. Co., Cleveland.	1
Federal Committee on Apprenticeship, Washington.	4
Federal Foundry Supply Co., Cleveland.	1
Federated Metals Div., American Smelting & Ref'g Co., Whiting, Ind.	3
Fisher Furnace Co., Chicago.	4
Foundry Equipment Co., Cleveland.	4
Freeman Supply Co., Toledo, Ohio.	4
Fremont Flask Co., Fremont, Ohio.	4
Frontier Bronze Corp., Niagara Falls, N. Y.	2
G	
Globe Steel Abrasive Co., Mansfield, Ohio.	4
Gray Iron Founders' Society, Cleveland.	1
Great Lakes Foundry Sand Co., Detroit	1
Great Western Mfg. Co., Leavenworth, Kan.	4
Grimes Molding Machine Co., Detroit.	4
Grob Brothers, Grafton, Wis.	4
H	
Benj. Harris & Co., Chicago Heights, Ill.	1
Hercules Powder Co., Wilmington, Del.	1
Herman Pneumatic Machine Co., Pittsburgh.	4
Hickman, Williams & Co., Cleveland	1
Hill & Griffith Co., Cincinnati, Ohio.	2
Hines Flask Co., Cleveland.	4
Hoffman Fdry. Supply Co., Cleveland	1
E. F. Houghton & Co., Philadelphia.	2
Hougland & Hardy, Inc., Evansville, Ind.	2
Hydro Blast Corp., Chicago.	4

Name	Hall	No.
I		
Illinois Clay Products Co., Chicago	2	
Illinois Testing Laboratories, Inc., Chicago	1	
Industrial Minerals Co., Lancaster, Ohio.	1	
International Harvester Co., Chicago.	4	
International Molding Mach. Co., Chicago.	4	
International Nickel Co., Inc., New York.	3	
Ironton Fire Brick Co., Ironton, Ohio.	1	
J		
Johnston & Jennings Co., Cleveland	4	
K		
Kindt-Collins Co., Cleveland.	4	
H. Kramer & Co., Chicago.	2	
The Kron Co., Bridgeport, Conn.	1	
L		
Lancaster Iron Works, Inc., Lancaster, Pa.	4	
Lava Crucible Co. of Pittsburgh, Pittsburgh.	1	
R. Lavin & Sons, Inc., Chicago.	4	
M		
J. S. McCormick Co., Pittsburgh.	4	
Macklin Co., Jackson, Mich.	4	
Mahr Mfg. Co., Div., Diamond Iron Works, Inc., Minneapolis.	4	
Mall Tool Co., Chicago.	4	
Malleable Founders' Society, Cleveland	1	
Marathon Chemical Co., Rothschild, Wis.	1	
Martindale Electric Co., Cleveland.	1	
Mathews Conveyor Co., Ellwood City, Pa.	1	
Metals and Alloys, New York.	2	
Metal Industries Catalog, New York.	2	
Michigan Smelting & Ref'g Div., Bohn Alum. & Brass. Corp., Detroit.	1	
Midwest Abrasive Co., Detroit.	1	
Milwaukee Fdry. Equipment Co., Milwaukee.	4	
Mine Safety Appliances Co., Pittsburgh.	1	
Modern Equipment Co., Port Washington, Wis.	4	
Monarch Engr'g & Mfg. Co., Curtis Bay, Baltimore, Md.	4	
James A. Murphy & Co., Hamilton, Ohio.	4	
N		
National Engineering Co., Chicago.	4	
Newaygo Engineering Co., Newaygo, Mich.	4	
Niagara Falls Smelting & Ref'g Co., Buffalo, N. Y.	1	
Wm. H. Nichols Co., Inc., Richmond Hill, L. I., N. Y.	4	
O		
S. Obermayer Co., Chicago.	1	
Oliver Machinery Co., Grand Rapids, Mich.	4	
Osborn Mfg. Co., Cleveland.	4	
P		
Pangborn Corp., Hagerstown, Md.	3	
Parsons Engineering Corp., Cleveland	3	
Peerless Mineral Products Co., Conneaut, Ohio.	4	
Penn-Rillton Co., New York.	1	
Penola, Inc., Pittsburgh.	3	
Penton Publishing Co., Cleveland	3	
George F. Pettinos, Inc., Philadelphia.	2	
Pittsburgh Crushed Steel Co., Pittsburgh.	4	
Pittsburgh Lectromelt Furnace Corp., Pittsburgh.	1	
Porter-Cable Machine Co., Syracuse, N. Y.	3	
Powermatic Ventilator Co., Cleveland.	1	
Productive Equipment Corp., Chicago.	1	
Pyro Clay Products Co., Oak Hill, Ohio.	1	
Pyrometer Instrument Co., New York.	4	
R		
Ramtite Co., Div., S. Obermayer Co., Chicago.	1	
N. Ransohoff, Inc., Cincinnati, Ohio.	4	
Republic Coal & Coke Corp., Chicago.	2	
Riehle Testing Machine Div., American Mach., & Metals, Inc., East Moline, Ill.	1	
Rotor Tool Co., Cleveland.	4	
Royer Fdry. & Machine Co., Kingston, Pa.	4	
S		
Safety Clothing & Equipment Co., Cleveland.	1	
Safety Engineering, New York.	1	
Safety Equipment Service Co., Cleveland	1	
Sand Products Corp., Detroit.	2	
Claude B. Schneible Co., Chicago.	4	
Schramm, Inc., West Chester, Pa.	4	
F. E. Schundler & Co., Inc., Joliet, Ill.	3	
Scientific Cast Products Corp., Cleveland.	2	
Semet-Solvay Co., New York.	1	
Seymour & Peck Co., Chicago.	1	
Simplicity Engineering Co., Durand, Mich.	4	
W. W. Sly Mfg. Co., Cleveland.	4	
Smith Facing & Supply Co., Cleveland	1	
Smith Oil & Refining Co., Rockford, Ill.	1	
Werner G. Smith Co., Cleveland.	2	
Spencer Turbine Co., Hartford, Conn.	4	
SPO, Inc., Cleveland	4	
Springfield Alum. Plate & Castings Co., Springfield, Ohio.	1	
Standard Conveyor Co., North St. Paul, Minn.	4	
Standard Sand & Mach. Co., Chicago.	4	
Steel Shot & Grit Co., Boston.	4	
Steelblast Abrasives Co., Cleveland.	1	
Sterling Grinding Wheel Div., Cleveland Quarries Co., Milwaukee.	4	
Sterling Wheelbarrow Co., Milwaukee.	4	
Frederic B. Stevens, Inc., Detroit.	1	
Superior Sand Corp., Massillon, Ohio.		
Swan-Finch Oil Corp., Chicago.	1	
T		
Tabor Mfg. Co., Philadelphia.	4	
Taggart & Co., Philadelphia.	2	
Tamms Silica Co., Chicago.	1	
Titanium Alloy Mfg. Co., Niagara Falls, N. Y.	1	
Toledo Scales Co., Toledo, Ohio.	4	
U		
United Compound Co., Buffalo, N. Y.	2	
United Oil Mfg. Co., Erie, Pa.	2	
U. S. Bureau of Mines, Pittsburgh.	4	
U. S. Dept. of Labor, Division of Labor Standards, Washington, D. C.	4	
United States Graphite Co., Saginaw, Mich.	1	
U. S. Hoffman Machinery Co., New York.	2	
U. S. Reduction Co., East Chicago, Ind.	2	
V		
Vanadium Corp. of America, New York.	2	
Vesuvius Crucible Co., Swissvale, Pa.	1	
W		
Wadsworth Core Machine & Equipment Co. Akron, Ohio.		
Walker Mfg. Co., Racine, Wis.	4	
J. D. Wallace & Co., Chicago.	4	
Western Metals Co., Chicago.	1	
Western New York Chapter of A.F.A., Buffalo, N. Y.	1	
Whitehead Bros. Co., New York.	3	
Whiting Corp., Harvey, Ill.	4	
Y		
Yale & Towne Mfg. Co., Philadelphia.	4	
Z		
Zanesville Sand Co., Zanesville, Ohio.	1	

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The Production Front

by H. R. Clauser
Assistant Editor

Speed-up was the urgent cry to the metal industries last month. WPB asked management and labor alike to push together for greater speed. Conversion gained impetus as many nonessential industries became more keenly aware of the fact that convert they must or perish.

The Production Requirements Plan continued to establish itself more firmly as the only effective method of control over scarce, vital materials and forms. It looked as though the outmoded system of granting blanket preference orders to whole industries would be lost in the reshuffle.

The steel situation remained generally the same with the needs far outstripping the supply, especially for plates. Structural mills were also being overloaded with orders, and there were some indications that soon all steel shapes would go under complete allocation control. Spring brought along with it a noticeable increase in scrap movement, but the shortage still remains and WPB, realizing this, organized a special salvage branch to fight that shortage.

In the non-ferrous field, announcement was made of a forthcoming vast expansion program for manganese. The copper industries were still under survey to determine their inventory conditions and compliance with priority regulations. Molybdenum is almost certain to come under complete allocation control soon, after having just escaped it last month due to lack of time.

Action in WPB

Early last month the WPB launched a vast production drive to simultaneously speed-up the conversion to war production as well as the output of already existing war plants. Joint plant committees composed of representatives of labor and management will play a major part in this production drive if both can forget their petty differences for a while. With labor, jealously guarding its hard-won gains of the past decade, and management still trying to temporize those gains, the friction between the two remains, even though there is a war going on.

Donald Nelson last month ordered a monthly report from industry on their progress in the war effort. The report will include the total value of war shipments during the previous month, man-hours worked, schedule of peak operation on war work, machine-tool status, etc. Such reports should give a general picture of the war program progress, as well as indicate the weak-spots.

On top of the production drive WPB ordered military contracts to be placed by negotiation instead of by competitive bidding. This policy will doubtless result in speedier procurement. Speed of delivery will be the primary consideration in awarding contracts, and many small firms, formerly unable to compete with the low-production costs of large companies, will be able to negotiate war contracts and guarantee fast deliveries.

Another action, quite essential, now underway is the organization of an inventory control branch within the priorities division. Excessive stocks of vital materials have accumulated in non-essential plants. More conservation and "freezing" orders will be issued from time to time, creating additional excessive stocks. All aluminum was first requisitioned in February; at least five hundred tons of white metal are now frozen in the hands of costume jewelers; it is predicted that copper will shortly be requisitioned with other metals to follow. It is an important and necessary task to get an inventory of all this material, move as much of it as possible into war use, scrap the rest for essential needs, and make equitable settlements with the companies from which it was requisitioned.

Conversion Goes On

All sorts of plans and methods were introduced from a variety of sources to hasten conversion last month. This is a healthy attitude and indicates that industry is intensively turning its mind to the job. And indeed it must, or be content to let its peace-time machinery go into hibernation, for the production of non-essential goods is rapidly ceasing.

WPB ordered a sharp cut in iron and steel, effective April 1, for the manufacture of beds, springs and mattresses, and is expected to reduce consumption by about 100,000 tons. Metal furniture was also hit by an order forbidding the production of a wide variety of metal household furniture.

Manufacture of radios and phonographs for civilian use must cease after April 22, and will conserve for war uses over the period of a year some 2100 tons of aluminum, 10,500 tons of copper, 280 tons of nickel, and 70,000 tons of steel.

"Juke" or music boxes will no longer be made, and the manufacture of bicycles will be curtailed to 42 per cent of last year's output. A ban has been placed on the use of bright-work, which involves aluminum, cadmium, chromium, copper or nickel for use in replacement parts and accessories for motor vehicles.

From all these restrictions it is evident that conversion is rapidly coming to be a necessity for most non-essential industries. It was announced that many automobile display rooms and repair shops were al-

(Continued on page 626)

ready being converted into factories for the production of war materials.

A plan has been developed and scheduled for trial in the Chicago area whereby a directory of war work to be sub-contracted will be made up. Selected prime contractors will list the work they need done by separate parts, classifying each by the machinery needed, tolerances required, etc. From this information the sub-contractors wishing to convert can fit their idle machines with the jobs available.

One of the biggest problems in converting small industries is the lack of both engineering and financial facilities. The state of Connecticut is attempting to solve the problem by setting up a three-man industrial engineering service in the state to advise small businesses how they can convert and how they might obtain financial assistance and war orders.

The Production Requirements Plan

During the next three months the priorities system will undergo a fundamental change, with the full adoption of the Production Requirements Plan by industry. It appears that this plan, developed after nearly a year of experimenting by trial and error methods, should finally provide an effective means of rationing out the scarce, essential materials to the places where they are most vitally needed.

The blanket preference ratings assigned to whole industries, which was the first method of control attempted, failed to provide an adequate system of control. There was no restriction on the amount of material that those ratings might be used to obtain, and, consequently, most of the material supplies were drained into the stock piles of those having top-priority ratings. Another shortcoming was that the system provided no easily workable plan for the small businessman to obtain priority assistance.

Several months ago total allocation was introduced and aimed at preventing this accumulation of stock, and providing closer control over the distribution of scarce materials and forms at the producers' level. The Production Requirements Plan is a modification and refinement of that plan and provides control of scarce materials all the way to the end product.

The big advantage of the PRP over previous systems is that the total demands for scarce materials for essential purposes will be known, and then the available supplies can be balanced against these demands and rationed out most equitably and to the places where the need is most urgent.

Under the Production Requirements Plan, a company files one application for priority assistance covering all its estimated material requirements over a three-month period. From this data, plus submitted information on the company's inventory and the product's end use, priority ratings are assigned for specified quantities of materials during a quarter. During the three-month period, if additional materials are required due to increased war business, applications may be filed for the additional quantities needed.

Steel

With the coming of spring, the raw materials situation has brightened up somewhat for the steel industry. The scrap business is in many respects a seasonal one, and with the advent of milder weather, scrap collections always perk-up. The movement of iron ore is also revived as the lakes thaw and the ore carriers begin their summer push to stock up the steel plants for the winter season. Nearly 90,000,000 tons of ore will have to be fed to the nation's steel furnaces in the current year.

In Buffalo some furnaces idle since December are underway again as the result of replenishing supplies of scrap. The Cincinnati area reports a great increase in the supply of scrap available. Steel operations in Detroit have been stepped-up as a result of the discovery of new scrap sources. The sad note in this optimistic strain is that the scrap situation, even with these encouraging signs, generally is only slightly better, and we are still scraping the bottom of the barrel.

The Bureau of Industrial Conservation appointed a special salvage division last month in an effort to expedite the movement of large scrap accumulations, which are being tied-up by such technicalities as ownership, title difficulties, high cost of demolition, and other complications.

Such a division to concentrate exclusively

ABILITY
Under the Hat
is What Counts!
R-S Furnaces are "tailor-made" for the particular heat-treatment of a particular product in a particular plant. This calls for engineering ability of high calibre—ability to pool experience and take advantage of local conditions for quick, quantity and quality production.
For resourcefulness, inventiveness and downright engineering skill, R-S Engineers are equal to the best. Add to this the foresight of preparation for quick delivery and you can do no better than to invest in an R-S Furnace, regardless of your product or heat-treating requirements.
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R-S FURNACES OF DISTINCTION

on the salvage of all available scrap was needed. The sources of scrap are by no means exhausted. Old buildings, bridges, street car tracks, sunken ships, old processing equipment in non-essential industries and dilapidated railroad, contracting and excavating equipment could yield thousands of tons of additional scrap. The chief difficulties are to hunt it out, organize its reclamation and move it into the most needy and depleted channels.

Because the demand for steel in all forms is steadily increasing, the point may soon be reached when WPB will find it necessary to exercise complete allocation control over all steel products, as it is now doing for steel plate. The structural mills producing rails, structural shapes, semi-finished materials and shell steel are already being taxed to capacity. Reports indicate that to insure rapid support to the Army, Navy, and Maritime Commission and lend-lease requirements, the War Production Board may even allocate steel ingots to the finishing units.

The abnormal demand for steel plates continued last month, and there were indications that April's out-put would fall at least 50 per cent behind the demand. The plan to use plates from the converted strip mills, formerly turning out sheet steel for automobile bodies, for merchant ship construction should in some measure alleviate the situation.

Non-Ferrous

The announcement last month that by 1943 domestic manganese production is expected to reach 600,000 tons a year is a far cry from the almost negligible amounts (30,000 tons in 1939 and 40,000 tons in 1940) produced previously.

This vast expansion program is the outgrowth of intensive studies and experiments carried on during past years by the U. S. Bureau of Mines and Geological Survey and by private groups to produce high grade manganese concentrates from 10 to 12 per cent ores.

Two-thirds of the expected expansion will be on 3 large projects. One project will use sulphuric and sulphurous acid leach, by which manganese sulphate is formed, then kiln-treated to produce 60 per cent manganese oxide concentrate. Another will extract 16 per cent manganese concentrate from 1 and 2 per cent manganiferous shales by ore dressing, followed by a blast furnace smelting process. The third will utilize a sulphurous acid method on 20 per cent ores to produce 60 per cent concentrates.

The copper industry is undergoing a careful survey to determine inventory conditions and the compliance with priority orders. A survey of 90 primary processors of refined copper has already been completed by the Compliance Branch of the Div. of Industry Operations, and an investigation is underway of scrap dealers, foundries and smelters of secondary copper and brass.

Molybdenum, which has assumed a most vital role in war industries since it began augmenting the use of tungsten, was just on the verge of complete allocation control last month. Lack of time cancelled the order, but the matter is certain to receive action soon.

Automatic Machine for Painting Small Shells

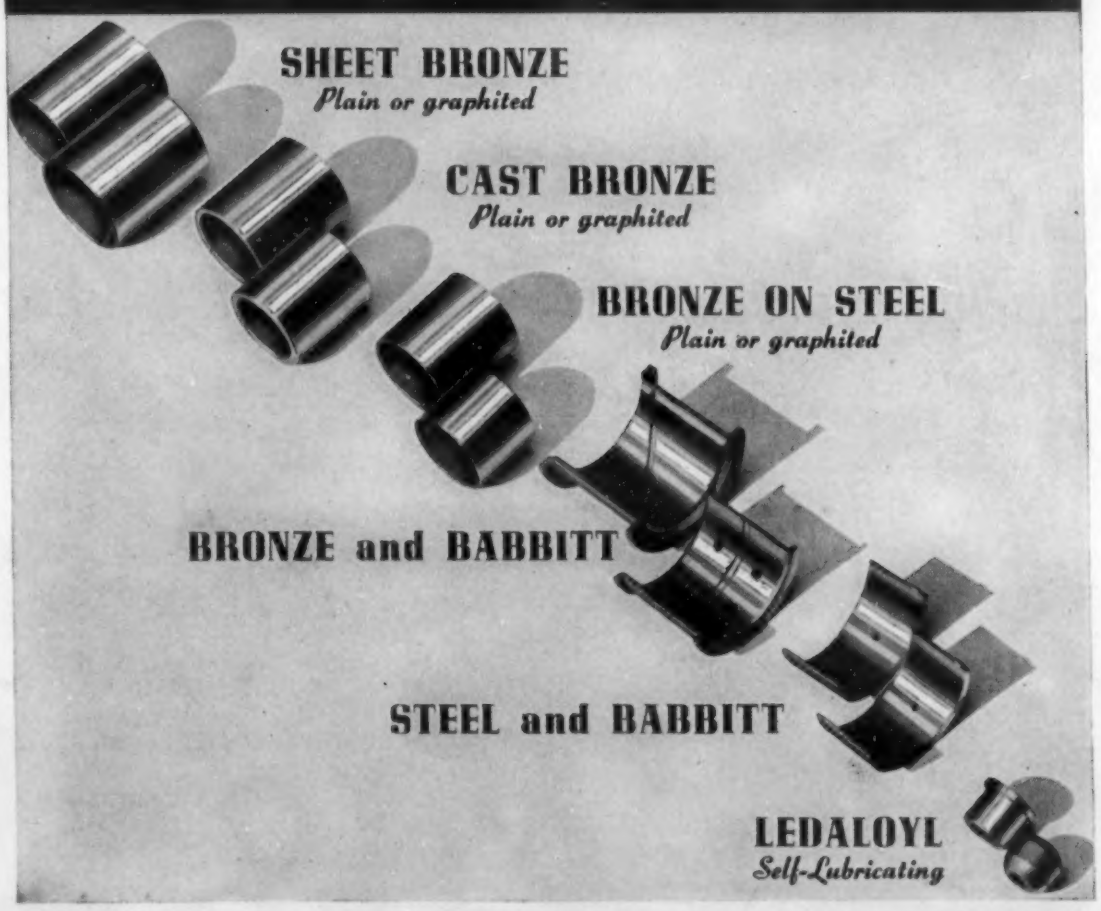
Painting is a most important operation in the production of shells and bombs. The great variety of types, sizes and painting requirements of these projectiles has necessitated the development of many different kinds of shell painting machines. Some are simple, standard, manually-operated equipment; others are complex machines with conveyors, drying ovens and paint circulation systems.

One of the more recent developments in equipment of this kind is a standardized automatic machine manufactured by *DeVilbiss Co.*, Toledo, Ohio, for small shells and shell parts. Machines of this type coat the exterior of 20 mm. shells at a rate of 2,000 per hr.

This machine is built around a "chain-on-edge," variable speed conveyor, which is of sufficient length to allow for a ten min. drying time at a production rate of 1,000 shells per hr. or a 5-min. drying time at a production rate of 2,000 shells per hr.

Spindles for supporting the shells are of the removable type, and are equipped with flat surface pulleys for rotation inside the spray booth. The spray guns are the automatic air piston type with adjustable cam-operated spray control.

Only JOHNSON BRONZE
makes every type of
SLEEVE BEARING



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Cleaner for Aluminum and Magnesium Parts

A new cleaner for aluminum and magnesium has been developed by *Hanson-Van Winkle-Munning Co.*, Matawan, N. J. This cleaner, known as "Matawan AL," is designed for cleaning aluminum in either sheets or castings, and it may be used for magnesium under the same conditions.

Used at a concentration of 4 oz. per gal. at 160 deg. F., it does not produce any etch or weight loss on aluminum sheet or casting after 2 hours' immersion. Machined and polished magnesium shows no weight loss or etching in 15 min.

In a number of tests on production castings, the time required for thorough cleaning was from ½ to 4 min., depending upon the type of work and amount of shop grease present.

This cleaner used at 175 deg. F. will etch the work slightly and slowly; thus, as the temperature is increased, the cleaning rate is increased, but at the expense of etching. It is not to be used as an electric cleaner—it is strictly a soak cleaner. To avoid etching, the temperature must be limited to 160 deg. F. At 175 deg. F. or higher, for faster cleaning, some etching will take place.

SPEEDS UP PRODUCTION • SAVES METAL
AND LABOR • IMPROVES QUALITY
The Detroit Furnace is a most useful metallurgical foundry production tool. Today, when armament production is so vital, the importance of Detroit Furnace speed, flexibility and economy stands at an all time high. These inherent characteristics of the Rocking Electric furnace result in lower metal losses, thorough uniformity, better quality and greater economy. For all around performance you simply cannot beat a Detroit Furnace. It does more things better.
Write for further facts or better still let us arrange for you to see a few of these furnaces in operation and talk to their owners yourself. Get the low-down first hand from those who know.
DETROIT ELECTRIC FURNACE DIVISION
KUHLMAN ELECTRIC COMPANY • BAY CITY MICHIGAN

Electric Metal Heater in Machine Gun Production

The present emergency is bringing out new uses for already-established products. *American Car & Foundry Co.*, New York, reports that their electric metal heater is

now being used in the selective hardening and annealing of many of the small parts used in the 50-cal. Browning machine gun.

Some of the advantages specifically reported in this new use for the heater are: savings in direct labor; more consistent results; elimination of the necessity for successive cleaning of the parts to remove lead, etc.; the provision for a larger amount of additional heat treating capacity in a relatively small space; and quick electric heat localized the heat at the desired section, thus speeding up production.

● For heating ovens or furnaces used in annealing of aluminum, as well as other materials, a new air heater is announced by *Westinghouse Electric & Mfg. Co.*, East Pittsburgh, Pa. Designed for temperatures of from 750 to 1150 deg. F., the unit has a heating element consisting of a one-piece nickel-chromium ribbon, spirally-wound around heavy porcelain insulators. Rating is 5 kw. for operation on 220-v. circuits. The complete heater is 2½ in. thick and requires a space 12 x 33 in. for mounting.

Bending Press

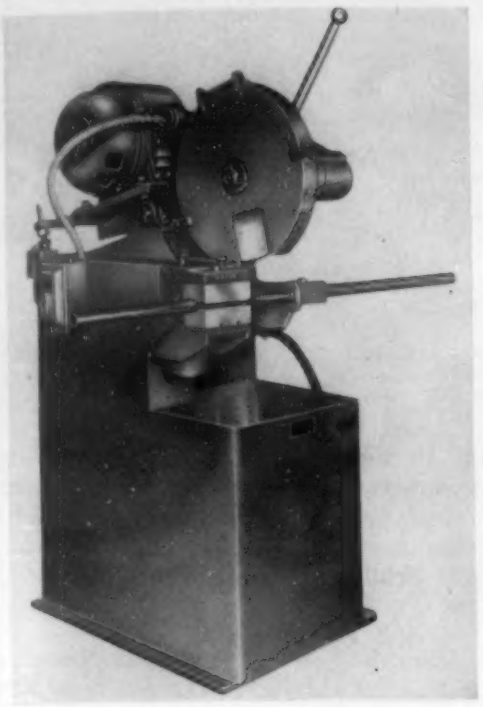
Steelweld Machinery Div. of Cleveland Crane & Engineering Co., Wickliffe, Ohio, announces a new bending press, with double bed and ram extension for bending and forming plate up to 20 ft. in width. Various plate thicknesses may be handled, depending upon the plate width. The machine will bend ½ in. plate up to 12 ft. in width, and even heavier plate that is less in width.

The frame is of the one-piece all-welded steel construction. All gearing is protected in metal enclosing covers, and shafting and machinery are located at the rear of the machine, thus preventing damage from bent-up plates, crane hooks, etc.

Bending, forming, blanking, drawing and multiple-punching operations may be performed on Steelweld presses. Gages and indicators provided make it a simple matter to obtain identical results repeatedly with a set of dies.

Semi-Automatic Tube Cut-Off Machine

Pines Engineering Co., Inc., Batavia, Ill., have recently added to their line of tube processing equipment a semi-automatic tube cut-off machine.



The unit, for high-production cutting of quantities of tube or rod to the same length, consists of a sturdy pedestal on which is mounted a motor-driven friction saw or abrasive disc on a swinging carriage. The saw spindle is multi V-belt driven, and the motor and saw, on a welded plate steel carriage, pivot on ball bearing pillow blocks. Limit of travel of carriage is controlled by readily-adjustable stops.

An automatic chuck, which holds the tube during the cutting operation, closes automatically as the handle on the pivoted saw carriage is pulled down. The chuck can be swiveled so as to provide any degree up to 45° cut for mitered corners in framework construction, and chucks can be changed quickly.

● A new cement for use in laying insulating firebrick has been introduced after an extensive development program by the Building Materials Div. of *Armstrong Cork Co.*, Lancaster, Pa. Because the new cement is made up of high-grade refractory clays and grog, chemically and physically similar to the components of Armstrong's insulating refractories, it provides a coefficient of expansion of the dried cement virtually the same as the brick with which it is used, thereby eliminating cracking and peeling caused by differential expansion.

Unique Magnetic Property in 18-8 Demonstrated

A steel strip that, when placed under a powerful magnet, waits about a minute and a half before it jumps toward it, is used by the *General Electric Research Laboratory*, Schenectady, N. Y., to show a delayed change in the steel's atomic arrangement. Exact knowledge of the nature of such changes is important in making magnetic materials for transformers and other electric equipment.

The strip is a common type of stainless steel containing 18 per cent Cr, 8 Ni and the rest iron. This metal is not ordinarily attracted by a magnet, because it usually contains a little nitrogen. This stabilizes the non-magnetic condition of the metal that occurs at temperatures above 1470 deg. F., and is reached as the steel is prepared. The nitrogen seems to cause friction, which prevents the atoms from rearranging themselves to the phase in which a magnet causes attraction.

If a piece of the nitrogen-free metal is heated to 1100 deg. F., then cooled, the magnetic phase does not return until it is down to 212 deg. F. It was found that if the heated strip is suddenly cooled by quenching in water, then placed under the magnet, it is not attracted, even though it is cooler than the temperature at which the change should occur. However, after 1½ min., it is suddenly attracted to the magnet.

The research laboratory reports that the atoms start rearranging themselves as soon as the strip is cooled, but it takes this time before a majority are shifted and at least a day before all reach a state of equilibrium.

Top flight designing engineers in many varied industries specify Ampco Metal, that wear-resistant alloy of the aluminum bronze class, as material for highly stressed parts. They know by actual experience that Ampco Metal lasts from five to fifteen times as long as ordinary bronzes.

Made in six grades with a range of physical properties, Ampco Metal is suitable for many varying applications. It has high tensile strength, controlled hardness and superior resistance to wear, corrosion and impact. Widely used for gears, bushings, bearings, slide plates, wear strips, feed nuts, leadscrew nuts, worms and worm wheels—to mention a few of hundreds of applications.

AMPCO LITERATURE Available

AMPCO METAL, catalogue 22
Ampcoloy—Industrial Bronzes Catalogue
Ampco-Trode Coated Aluminum Bronze Welding Rod
Ampco Metal in Machine Tools
Ampco Metal in Bushings and Bearings
Ampco Metal in Dies
Ampco Metal in Acid-Resistant Service
Ampco Metal in Aircraft
Ampco Metal Centrifugal Castings
Ampco Metal in Heavy Machinery
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Perhaps you have a troublesome part that is weak or failing—causing loss of production time or creating customer dissatisfaction. Investigate Ampco Metal for this application. Our engineers are at your service. Typical Ampco literature is listed in the panel at the left. **Write for the bulletin that interests you.**

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Solder-Flushed Electrical Contacts

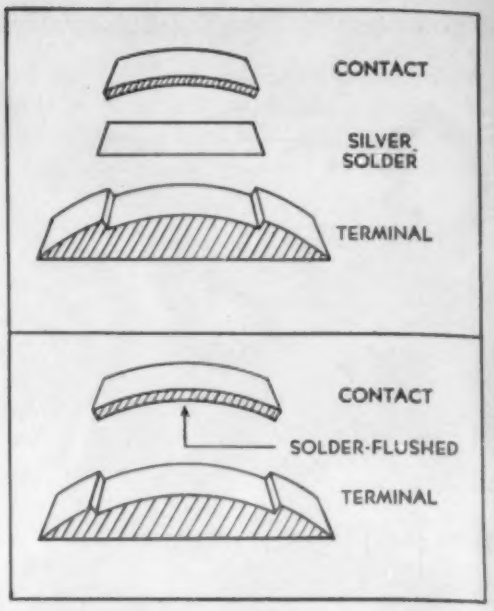
Substantial savings in production time are reported when making electrical contact assemblies by the use of solder-flushed contacts supplied by *Gibson Electric Co.*, Pittsburgh, Pa., and in some instances, an operator can double the number of contact assemblies brazed in a given time.

Solder-flushed contacts are contacts that have been coated on one side with silver solder so that they may be applied immediately to the terminal. The contact is simply placed on the terminal and brazed in an electric welder, eliminating the extra operation of placing a separate piece of solder between the contact and the terminal.

Besides the savings in time and production costs when solder-flushed electrical contacts are used, a uniform distribution of solder in the joint between the contact and the terminal is assured. Complicated contact assemblies, which are impossible or very difficult to make when a separate piece of solder is required, are more easily brazed with solder-flushed contacts.

Solder-flushed contacts permit brazed joints to be used in contact assemblies, and provide a 100 per cent electrical and mechanical bond over the entire surface between contact and terminal.

In the accompanying illustration, the top



half shows the brazing method with an ordinary contact; the lower portion shows brazing with solder-flushed contacts, eliminating the need for inserting a separate piece of solder.

● A new line of cement-asbestos pipe, now being marketed by *United States Stoneware Co.*, Akron, Ohio, is specially designed for the handling of a wide range of mildly corrosive solutions. This pipe can be lined with either a standard coating or a corrosion-resistant lining material, known as "Tygon," which offers high resistance to abrasion, along with immunity against a large number of corrosive chemicals.

Air Conditioning of a Foundry

A new solution to the old foundry problem of free dust and sand settling into molds and causing casting rejects has been found by the *American Magnesium Corp.* in its Cleveland, Ohio, foundry.

The solution lies in a new heating and ventilating system, which by means of amount, direction and rate of air delivered, prevents dust from being blown about and dilutes the unpleasant smoke-laden atmosphere.

The equipment used consists of 10 Carrier thermadjust heat diffusers, supplying 135,000 cubic ft. of outside air per min. to the foundry. Although the foundry is 80 ft. wide, 160 ft. long and 35 ft. high, the units maintain comfortable working conditions.

Mounted in an inverted position along the side walls, the heating units are 9 ft. above floor level. From long slotted outlets, a low velocity flow of outside air is fanned downward and toward the center of the floor at the correct temperature to offset heat losses through the ventilators.

This system is described by *Carrier Corporation*, Syracuse, N. Y., as a marked improvement over the older types of heating systems frequently used in foundries. One of the advantages claimed for the system is that overblows, which swirl dust and other impurities around the foundry without forcing them toward the ventilators, are eliminated by discharging the air at low velocity.

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99.99+% pure

The electrolytic refining process, originally conceived for the treatment of complex lead-zinc ores, consistently produces zinc of the highest purity. 42282

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Meetings and Expositions

ELECTROCHEMICAL SOCIETY, spring meeting. Nashville, Tenn. Apr. 15-18, 1942

ANNUAL OPEN HEARTH AND BLAST FURNACE CONFERENCE, AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS. Cincinnati, Ohio. Apr. 16-17, 1942.

NATIONAL PETROLEUM ASSOCIATION, semi-annual meeting. Cleveland, Ohio. Apr. 16-17, 1942.

AMERICAN CERAMIC SOCIETY, annual meeting. Cincinnati, Ohio. Apr. 19-25, 1942.

AMERICAN ZINC INSTITUTE, annual meeting. St. Louis, Mo. Apr. 20-21, 1942.

AMERICAN CHEMICAL SOCIETY, semi-annual meeting. Memphis, Tenn. Apr. 20-24, 1942.

AMERICAN FOUNDRYMEN'S ASSOCIATION, annual convention. Cleveland, Ohio. Apr. 20-24, 1942.

ASSOCIATION OF IRON & STEEL ENGINEERS, spring meeting. Hamilton, Ont., Canada. Apr. 27-28, 1942.

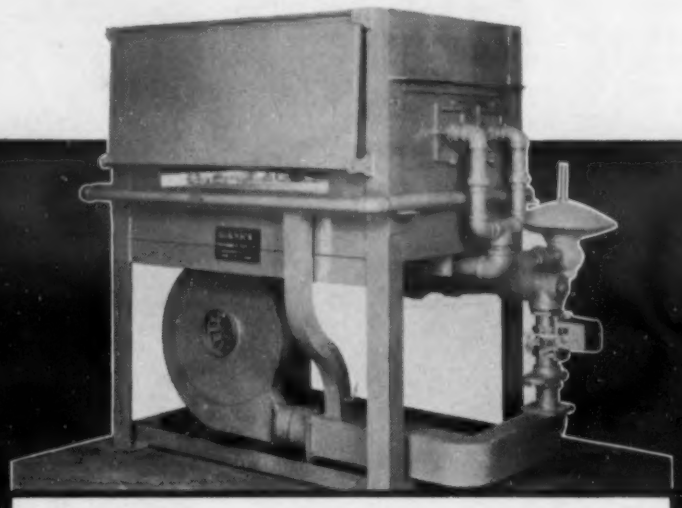
NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION, spring conference. Hot Springs, Va. May 10-15, 1942.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, semi-annual meeting. Boston, Mass. May 11-13, 1942.

SOCIETY OF AUTOMOTIVE ENGINEERS, semi-annual meeting. White Sulphur Springs, W. Va. May 31-June 5, 1942.

ROLNICK FORGING FURNACE

A new gas-fired furnace with improved air blast curtain which prevents excessive loss of heat and protects the operator. . . . Uniform temperature is maintained automatically by motorized butterfly valve connected to pyrometer controller . . . Air blower is conveniently mounted as an integral part of the unit.



Rolnick builds a complete line of fuel-fired and electrically heated treating furnaces up to twenty-five square feet of hearth area. Our specialty is adapting the furnace to suit specific requirements.

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MANUFACTURERS OF HEAT TREATING EQUIPMENT
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All branches of the armed services will use equipment containing Wilbur B. Driver Co. alloys

- Nickel-chrome heat-resisting alloys
- Copper-nickel electrical resistance alloys
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Manufacturers of "TOPHET"* *the Nickel-Chrome Resistance Wire*

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New Method for Producing High Purity Chromium

A form of sponge, or powdered, chromium metal that under certain conditions attains a purity of 99.8 per cent—higher than any chromium used in present commercial manufacturing—has been produced from both low- and high-grade domestic chromite ores through a process developed by the *Bureau of Mines*.

Immediate benefits of the improved form of chromium metal are expected to be the development of new and important alloying processes in the metal industries of the nation. Its high purity and powdered form render it valuable in the manufacture of special steels, brass and bronze materials, and in alloys that are subjected to high temperatures, such as electrical heating elements.

Successfully carried through the laboratory stage to a point where pilot plant tests are justifiable, the new reduction process may, under favorable circumstances, permit the utilization of a large amount of America's "off-grade" chromite ores at costs comparable to the existing prices of low-carbon ferro-chrome. However, its future in this field will depend chiefly upon the availability and cost of chlorine, the chemical used extensively in producing this new metallurgical material.

Low temperature reduction without sintering is the basis of the process developed by the Bureau of Mines during 5 years of research and investigation in obtaining pure chromium metal. The fundamentals consist of the chlorination of chromite ores at elevated temperature, sublimation and separation of volatile chlorides, and reduction of chromium to metal by hydrogen. Sponge chromium of at least 99 per cent purity may be produced, and if specially purified chloride is used, the product may reach 99.8 purity.

Sulphurized Cutting Oil

A new sulphurized cutting oil has been produced by *Pawling Refining Corp.*, Port Chester, N. Y., for high-carbon steels, which is said to speed up the production of machine tools and machining of steels high in carbon content.

This new oil is reported to carry more sulphur content than ordinary cutting oils and thus produces a much cooler and faster cutting operation. The oil is transparent, which enables the machine operator to see the cutting edge constantly. This is highly important in precision work.

The development of this new cutting oil was made possible through the discovery of a new process that permits complete distillation of castor oil producing a castor concentrate with new properties.

Other products announced by this company, as derived from its newly discovered process, are: a new core oil of greater efficacy; a new penetrating oil; drawing oil for drawing wire; lapping oil; roll oil for steel rolling mills; and others.

High Tensile Strength Solder

A special solder developed for the soldering of all hard-to-solder metals, such as aluminum, aluminum alloys, die cast, Dowmetal, Almico, etc., has been announced by *Lloyd S. Johnson Co.*, Chicago.

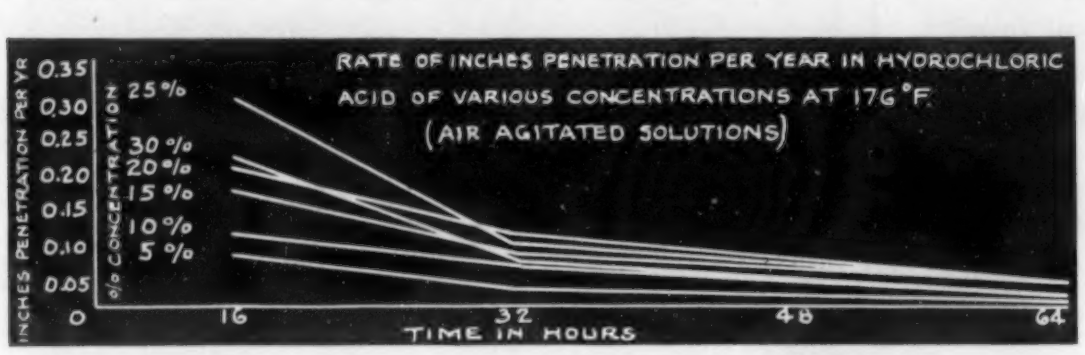
The material is reported to be exceptionally free-flowing, and provides unusual tensile strength in sheet metals and extruded aluminum. It retains color of aluminum and Dowmetal, and is corrosion resistant. The solder comes conveniently rolled ⅛ in. sq. and runs approximately 270 in. to the lb.

Profilometer Accessory

A new accessory unit for use with profilometers has been announced by *Physicists Research Co.*, Ann Arbor, Mich. This unit, known as a "power pack," has been designed to make possible the use of the instrument on a.c. lines.

Profilometers, instruments used for the measurement of surface roughness of metal parts and finishes and providing direct dial reading in true inch units, until recently have been self-contained with batteries that permitted full portability.

With the increasing need for their uninterrupted use in one location, particularly on 3-shift inspection operations, the power pack was developed so that power could be supplied from a 115-volt, 50-60 cycle a.c. source.



The action of Hydrochloric Acid on Durichlor produces a protective film by the interaction of metal and acid. The initial losses are due to time required for the formation of the protective film and need not be considered.

DURICHLOR TECHNICAL DATA SHEET

DAYTON, OHIO

Durichlor is a special high silicon iron almost entirely resistant to Hydrochloric Acid in all concentrations and at all temperatures up to the boiling point.

COMPOSITION: Essential nominal chemical composition: Fe; Si 14.5%; Mo 3%; Mn; C; P; S; each less than 1%

PHYSICAL CHARACTERISTICS:

Specific gravity	7.0
Weight, pounds per cu. in.	.255
Melting point, degrees F.	2300
Electrical Resistivity, Microhms per Cm^3, 0°C.	63
Thermal conductivity (Ag-1) 0°C.	0.125
Hardness, Rockwell C.	52
Tensile strength (½" diam. bar)	17,000 lbs. sq. in.
Coefficient of Expansion:	
(32-212 deg. F.)	0.0000036
(32-2300 deg. F.)	0.0000156
Form available	Cast
Method of fabrication	Welding
Machineability	By grinding only
Design	Similar to cast iron

PRODUCTS AVAILABLE: Pumps, valves, pipe and fittings, exhaust fans, mixing jets, tank outlets, ejectors, kettles, etc.

RESISTANCE:

To Hydrochloric acid, all concentrations and temperatures up to boiling point.
To Sulfuric acid, all concentrations and temperatures.
To Nitric acid, all concentrations and temperatures.
To Phosphoric acid, all concentrations and temperatures, except in presence of hydrofluoric.
To Heat, good. Sudden temperature changes to be avoided.
To Abrasion, excellent.

APPLICATIONS: Wherever corrosive liquids, wastes or gases are handled . . . in chemical manufacture; in pickling; producing and refining petroleum; bleaching, etc.

Technical Data on DURIMET next month

THE DURIRON COMPANY INC. DAYTON OHIO
DURIRON · DURICHLOR · DURIMET · DURCO STAINLESS STEELS
CORROSION-RESISTING DURCO ALLOYS & EQUIPMENT THE DURIRON CO. INC. DAYTON, OHIO

Slants and Plants

General Electric Co., Schenectady, N. Y., announced recently that in 1941 the company paid its employees over $95,000 for 12,453 suggestions. Among the many suggestions was one halving the time required for a step in making bearings and bearing rings for battleships. Another suggestion saved 12,000 lbs. of a special steel by cutting it in strips 7/32 in. narrower.

Production facilities of *Wilkening Mfg. Co.,* Philadelphia, have been increased for making piston rings by the addition of a building for housing the coating department.

A ten weeks' course in Powder Metallurgy, conducted by W. J. Baëza, is beginning early this month at the College of the City of New York. No tuition or fees will be required.

Pyrometer Instrument Co., New York, has moved to larger quarters and is now making pyro-optical instruments in its own laboratory.

Mathieson Alkali Works, Inc., New York, reported that unless chlorine cylinders are kept in constant circulation, many users may have difficulty in obtaining adequate supplies.

Materials salvage operations have been stepped up and will continue to increase, according to *Glenn L. Martin Co.,* Baltimore.

The scrap-aluminum recovery alone has risen to 90 per cent of the company's waste metals this year.

A new two-wheeled, light-weight, pneumatic-tired trailer for mounting 200, 300 and 400 amp. Hobart electric drive welders is now in regular production at *Hobart Brothers Co.,* Troy, Ohio. Designed for road towing up to 35 mi. per hr., this unit should prove useful for hurry-up trips to different locations for emergency production, maintenance and repair work. The trailer is so designed that mounting it is accomplished easily by means of 3 bolts in the frame of trailer, which register with 3 holes in the legs of the welding machine.

Heat Exchanger for Oil Cooling

A new evaporative-type liquid heat exchanger for use in removing heat and controlling temperatures of lubricating, machining, grinding and quenching oils, water-quenching baths, etc., has been developed by *Niagara Blower Co.,* New York.

The unit consists of a casing that encloses tubes through which the hot liquid passes. These tubes are cooled by applying the principle of evaporative cooling. Water from a spray system constantly drenches the tubes, while air is drawn through the sprayed coils by a fan. Only the water evaporated is consumed, and is claimed to result in saving 95 per cent of the water ordinarily used with shell and tube heat exchangers.

The heat exchanger can be used to advantage in the cooling of special steel parts, since it is reported that the liquid entering the quenching bath can be controlled within 2 deg. F. by the use of a thermostat operating by-pass dampers.

Dry and Wet Abrasive Belt Surfacer

A newly-designed dry and wet abrasive belt surfacer has just been placed on the market by *Hammond Machinery Builders, Inc.,* Kalamazoo, Mich. In many operations, wet abrasive surfacing has the important advantage of permitting faster cutting at lower costs, prevents discoloration, fracturing, chipping, warping, and eliminates dust and fire hazards.

The machine can be adjusted from vertical to horizontal position while it is running. The belt tension and tracking device can likewise be adjusted while running. The machine is totally enclosed for safety, and is arranged for an individual dust collector or for connection to an exhaust system.

The abrasive belt pulleys are made of cast iron, and are dynamically balanced. The work table can be adjusted to any desired working angle, and is available as bench or floor model.

Portable Magnetic Separator

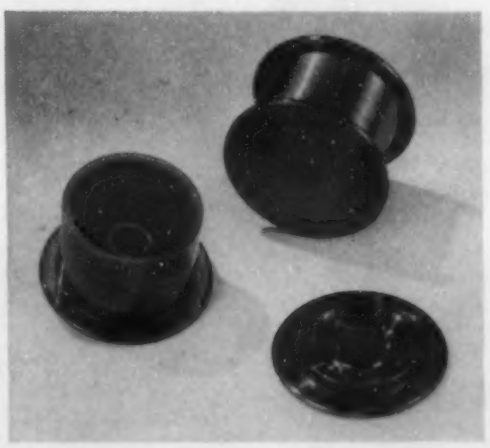
A new inclined portable pulley type separator has been announced by *Dings Magnetic Separator Co.,* Milwaukee, Wis. The unit adaptable to many industries for removing iron from all types of materials is most widely applied in foundries for cleaning foundry sand and in the metals-refining industry for reclaiming and purifying non-ferrous scrap.

The new separator is said to be a compact, light and portable unit that can be moved around a shop easily. The inclined design makes it easy to shovel material into the endless belt at one end and discharge at any required height at the other end into bins or trucks.

Plastic Spool for Wire

An interesting application of plastics which helps to conserve aluminum for other essential uses is the new tungsten wire spool developed by *Callite-Tungsten Corp.,* Union City, N. J.

This spool is produced from Bakelite



phenolic material in two sections at a reduction in cost of 20 per cent. Even though the two halves fit together very tightly, they are cemented so as to insure a permanent bond.

Corrosion-Resisting Oil

A new anti-rust oil, known as Miccroil, has just been introduced by *Michigan Chrome & Chemical Co.,* Detroit. Among its principal qualities is its high flash point. For this reason, the possibility of fire hazards is reduced to a minimum. It dries in 30-45 min.; it is light in color, transparent, and does not alter the appearance of the part on which it is applied.

The oil is applied by hand dipping, and is of a consistency that is said to assure a uniform and extremely effective protective film over the entire surface. It can be used on practically any surface that must be guarded from oxidation or corrosion, including aircraft parts, gages, precision tools, other machined or polished parts, stampings, etc.

1000-ton Straightening Press

A giant 1000-ton straightening press, standing 21 ft. high, has just been delivered by *Watson-Stillman Co.,* Roselle, N. J., to Penn Forge Co. It is used to straighten shafts from 12 in. to 18 in. in diam. and from 7 ft. to 60 ft. long.

For handling and positioning work, there are two sets of rollers, each set mounted on a hydraulic lifting ram, which in turn is mounted on a motor-driven carriage running on rails between the columns of the press. One set of rollers is motor-driven to rotate the work as required.

When the work is positioned, the lifting rams under the rollers lower it onto two bending blocks. Each bending block is independently motor-driven for separation adjustment from 2 ft. 3 in. to 18 ft.

Pressing speeds are 470 in. per min. advance, 15½ in. per min. pressing and 470 in. per min. return. The stroke is 38 in., opening 48 in., and space between columns 48 in. The press pump is a rotary piston oil type driven by a 50 h.p. motor.

News of Metallurgical Engineers

H. J. French, International Nickel Co., has been appointed senior technical consultant, in charge of Metallurgical & Specifications Section of the Iron and Steel Branch, WPB. . . . *Robert C. Woods,* formerly with Bell Aircraft as physicist specializing in radiography, is now research engineer for Taylor Winfield Corp.

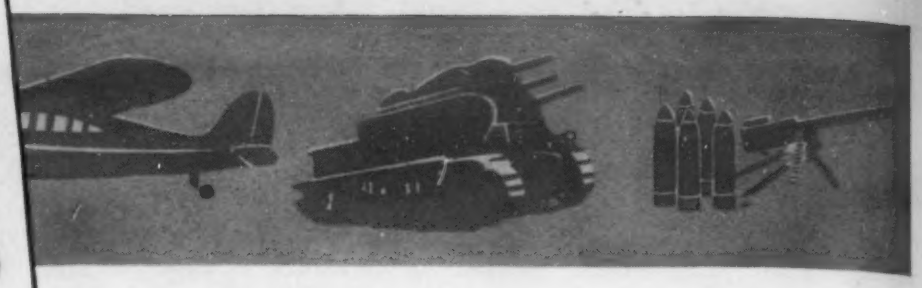
Robert D. Williams has been named a research engineer on the technical staff of Battelle Memorial Institute, where he will assist in welding research. . . . *Harold R. Wegner,* formerly metallurgist with Brown-Lipe-Chapin, Div. of General Motors, has resigned to accept the position of metallurgist and plant superintendent with Syracuse Heat Treating Corp.

G. S. Mican, Carnegie-Illinois Steel Corp., has been named to general superintendent, production planning, at the South Chicago works. He was previously assistant division superintendent of rolling. . . . *John Wilson* has been made production superintendent of Jessop Steel Co.

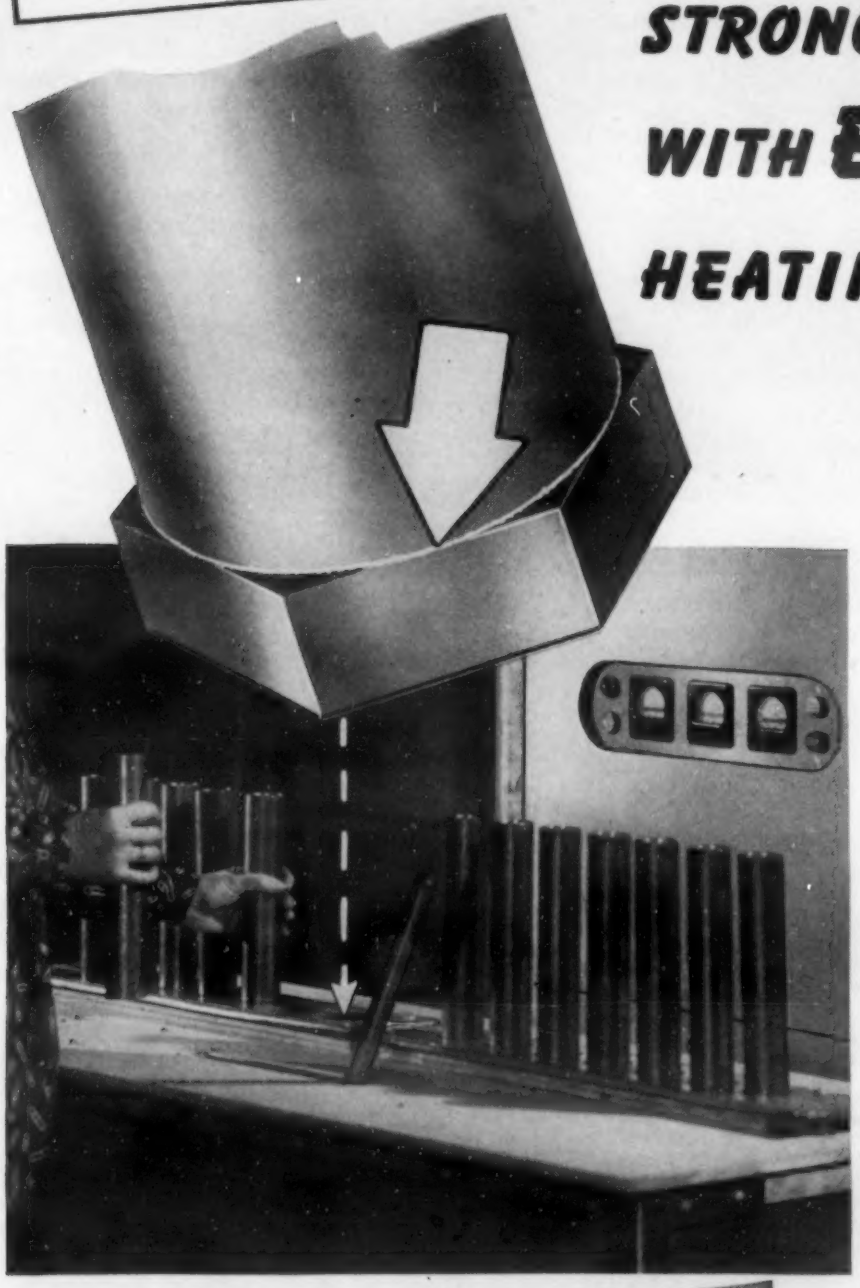
Another

FROM THE THOUSANDS OF VICTORY PRODUCTION JOBS BEING BRAZED WITH . . .

EASY-FLO



STRONG JOINTS—120 PER HOUR WITH EASY-FLO PLUS A FAST HEATING PROCEDURE!



This job is another example of the high production metal joining that can be obtained by the fast action of EASY-FLO brazing alloy plus a procedure designed to facilitate handling and give fast heating.

THE JOB— Joining the steel nosepiece to a steel shell.

PROCEDURE— After fluxing, *a ring of EASY-FLO is preplaced* in a groove in the nosepieces which are then assembled in the shells. Next the assemblies are placed, 7 at a time as shown at the left, in the hexagonal shaped holes in the coil fixture of an induction heating unit. The switch lever is thrown and in a matter of seconds the 7 joints are made—joints that meet all physical requirements.

One feature of EASY-FLO is that *thin films make the strongest joints.* This cuts down the amount of alloy needed. On the job illustrated, it takes only 40 ounces of 3/64" of EASY-FLO wire to make 1000 joints. Preplacing the alloy gives accurate control of the amount of alloy used.

★ REASONS WHY EASY-FLO MAKES STRONG, SOUND JOINTS IN QUICK TIME . . .

Free-flowing to an exceptional degree, EASY-FLO penetrates, the instant its flow point is reached, to all parts of a joint and into the surfaces of the metals, actually alloying with them. Add to this fast and complete penetration the low working temperature of EASY-FLO—1175 F.—and you have the answer to EASY-FLO brazing: SPEED plus RELIABILITY. Complete details are given in Bulletin No. 12.

MAYBE WE CAN HELP YOU SPEED UP YOUR BRAZING . . .

If you can use increased production—or better joints—on any ferrous, non-ferrous or dissimilar metal joining job, we'll be glad to send a Field Engineer to show you what EASY-FLO can do and help work out the most effective handling and heating procedure for the job.

For complete EASY-FLO details, write for Bulletin No. 12.

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METALLURGICAL ENGINEERING shop notes

How Stampings May Replace Forgings in Design

by Herbert Chase

At the present time forge shops are being taxed to capacity to drain off the flood of work which has engulfed them as a result of the war program. At the same time, many stamping presses, less adaptable to war work, are idle. The accompanying illustration may well suggest ways in which heavy stampings can be made to replace forgings and thus, in some measure, aid in relieving the pressure on forge shops.

The parts shown are called cam tube brackets and are employed as elements of heavy road equipment manufactured by Gar Wood Industries, Detroit. The stamping at the right is relatively simple to produce, as it requires only a simple blanking die and a die for forming the blank to shape. Some, if not all the holes can be punched in the blanking operation.

The welds are simple, and can be made rapidly. Both blanking and forming operations are performed quickly, and the finished piece is lighter and serves its purpose as well as the forging. Besides this, no heating is required.

In contrast with this, the forging requires a die, which is not inexpensive, to shape the piece and one to shear the flash. Naturally, the billet used has to be heated and the finished forging is not as smooth as the stamping. Moreover, all the holes in the forging have to be drilled, usually requiring a more expensive jig than for the stamping. In any event, the stamping has proved less expensive and meets all requirements.

There are, of course, many forgings for which stampings cannot be substituted, but if the designer uses judgment and consults a capable producer of stampings when in doubt as to what can be accomplished, it will be found that stampings can be substituted for forgings in many cases with savings in cost and in time of production.

Using High-Lead Solders

In the effort to conserve tin, the War Production Board is urging the use, wherever possible, of solders higher in lead and lower in tin than those heretofore employed. One of the difficulties encountered in the use of high-lead solders is their high resistance to spreading at points to be soldered. For years the Lamp Department of General Electric Co., Cleveland, Ohio, has been using a small amount of high-lead solder, and recently the use has been very greatly expanded in accordance with the tin conservation program.

This practice involves the use of small pointed gas fires that heat both the work and the solder at points of soldering. When using a solder containing 97.25 per cent Pb, 2.5 Ag and .25 Cu, it has been found that natural gas fires do not produce satisfactory spreading. By adding hydrogen to the gas-air mixture, this solder can be made to spread satisfactorily.

Also, this practice has been applied to a solder containing 95 per cent Pb and 5 Sn with satisfactory results. Most artificial gas contains hydrogen, and it has been found that artificial gas-air fires can be so adjusted that some of the high-lead solders will spread.

In general, the higher the tin content of the solder, the better are the spreading characteristics. It is not always desirable to have maximum spreading, so the element of control is important in some cases. With high-lead solders, the use of hydrogen with a controlled fire makes possible to a considerable extent the control of spreading. For proper control, the burners should be equipped with valves to adjust, separately, the flow of gas, hydrogen and air.

—Report by Metals and Substitution Group, National Academy of Sciences, National Research Council.

(MORE SHOP NOTES ON PAGE 636)

Tools for Machining Aluminum

It is most essential to maintain sharp cutting edges on all types of tools employed on the machining of aluminum parts, whether wrought or cast. Not only must cutting edges be sharp, but the tool surfaces adjacent to such edges must be smooth and highly polished. Rough surfaces enable chips to adhere. Dull edges will tear the metal and score the work instead of cutting. Tools must, therefore, be ground to a fine edge mechanically and not freehand, on suitable fine abrasive wheels, and in many instances must be honed or lapped. Oilstoning to a superfine edge and smooth surface may also be necessary to maintain keenness between grindings.

Tools generally used for cutting mild steel will require some slight modification in order to adapt them for working aluminum alloys satisfactorily.

Much higher speeds can be and should be employed, and copious flooding or even pressure-fed supplies of coolant must be directed at the points being machined. This question of the most suitable types of lubricants should be taken up with the companies specializing in oils and cutting compounds. Several types are now marketed that are claimed to give highly satisfactory results.

Single point tools for turning and boring differ somewhat from those used for steel, and must have considerably less surface of contact with the work; that is, the cutting edge must be narrower and sharper. The angles constituting rake and clearance ensure this. Tools for turning should be provided with clearance of 8°-10°. Top rake should be a minimum of 20°, while side rake should be between 10° and 20°.

Close attention to these points, and employing highest quality high speed steel or carbide tipped tools honed to a fine edge should ensure a smooth-machined surface. Some of the aluminum alloys now being used are extremely abrasive, so that only carbide tipped tools or diamond tools will maintain clean, keen cutting edges for any length of time.

High cutting speeds with fine feeds give much better results than heavy cuts or heavy feeding, although considerable heat is generated, thus demanding recommended coolants to offset this.

In the same way, milling cutters, saws and end milling cutters must have greater clearance and fewer teeth than tools usually employed on steel.

Reamers and milling cutters should have considerable rake to the teeth and plenty of room for chips to escape, while flutes on these and on twist drills should be polished.

Thread-cutting on aluminum is probably one of the most difficult operations where a good smooth surface is required. Taps and dies should be undercut at the edges, and the flutes of cutting faces should be polished smooth. Special taps are now available for the working of aluminum, on which a short spiral lead is provided and extra rake given.

One of the most troublesome items in tapping is the backing out of the tap after completion of the thread, so that when considering threading work of any size, a collapsible tap should be used or thread milling be resorted to. Similarly, self-opening dies are much more satisfactory than dies which have to be reversed and run off.

—The Metal Industry

Many times users of fire brick and other refractories neglect to take proper care of them before they are put into service. There are two precautions that add more to the life of refractories than the best of care after they are laid: (1) Care should be taken to unload them without breaking any corners or surfaces, as the fused face of the brick is much more heat resistant; and (2) until they are ready to be used, this is of the utmost importance, they should be stored in a dry place, and in no event be exposed to the elements. Thousands of good firebrick and cupola blocks have been blamed for early failure in service, after they had been allowed to soak up rain and in some cases been frozen.

—Pig Iron Rough Notes
Slöss Sheffield Steel & Iron Co.

Contour Machining Aids

by H. J. Chamberlain
Continental Machines, Inc.

Contour machining offers a method of metal shaping which is time- and material-saving in many applications. In the use of the contour machining process, close attention to a few operating details will work for maximum efficiency.

Operators of contour sawing machines should not overlook the job selector and variable speed controls. These are dependable pilots to maximum cutting efficiency. In cutting, the widest saw possible should be used even if it means two or three different widths to complete a complicated outline. Only two minutes is usually required to change a saw.

Coordination of correct speed and saw selection, plus good judgment for feed control go far in making for true contour machining technique. Strict adherence to these principles permits cuts through 18-in. thicknesses on tough steels with standard equipment and up to 30 in. with specially-designed machines.

Railroad rails that have seen their best days in service and have to be replaced are being converted into army cots. Used rails are rolled into various shapes, such as light bands and angles, and are sold to army cot and bed manufacturers. One steel company recently devised a special heat treatment to make the product of these used rails more ductile. The used rails are a highly preferred grade of scrap for melting in open hearth furnaces; therefore, the company's rerolled rail department has to compete with the melting department when a tonnage of used rails comes on the market.

—Steel in Defense
American Iron and Steel Institute

They laughed when he sat down to write—they didn't know it was a SHOP NOTE *he was writing; they didn't know that he would get some extra pin-money for his original, practical hints and kinks that were published in M & A.*

In the radiographic examination of welded seams, "sunflowers" are frequently observed. These are clusters of cold shuts caused by striking the arc and leaving small bits of unfused metal in the joint. It has been reported that such "sunflowers" can be eliminated by correct technique in striking the arc. This procedure is to strike the arc and weld backwards for a few seconds before reversing the direction of travel and continuing along the joint. In this manner, enough heat is built up at the beginning of the deposit from the new electrode to guarantee the melting and subsequent fusion of the small particles that would otherwise lead to a "sunflower" in the X-ray negative.

—Welding Briefs
Metal & Thermit Corp.

Surface Cleanliness Test

by Chester E. Unger
American Foundry Equipment Co.

For successful metal finishing it is imperative that the parts be chemically clean and free of all foreign material. There are a number of simple tests, which can be made in even the smallest shops, to determine the chemical cleanliness of such metal pieces after the cleaning operation.

The simplest of all tests on iron castings, forgings, sheet steel (except stainless), etc. is to make a saturated solution of copper sulphate (blue vitriol) to which a slight amount of sulphuric acid (1 per cent) has been added. The use of this solution serves to detect the presence of iron in any form including its alloys, by forming a bright yellow copper coating on the surface of the article tested. Where sand, iron oxide or foreign material is present, the substance will remain in its original color or may be blackened.

The material suspected of being chemically unclean can be tested either by immersion in the solution or by rubbing the work with a swab. Special emphasis should be given to the fillets and cavities in the piece, if enameling or plating is to follow. It is a good idea to renew the solution or to re-dip the swab for each test to be made.

In checking the cleanliness of a complete batch of metal parts in the cleaning machine, it is advisable to test pieces from various parts of the load to make certain the entire load is cleaned. Should certain pieces still have some traces of foreign material adhering, a few minutes longer cleaning application becomes necessary.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

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Plaster Patterns for the Foundry

"Plaster Patterns for Foundry Use." Henry Plucknett. *Foundry Trade J.*, Vol. 66, Jan. 15, 1942, pp. 35-36, 39. Descriptive.

Plaster patterns constitute one of the most revolutionary changes in foundry practice during the last half century, affecting not only the pattern maker but also foundry technique. By this method castings can be produced in one-half and even one-fifth of the time previously taken.

In using wood, several pieces invariably have to be joined together in such a way that glue must be used. Plaster of paris owing to its natural quicksetting properties, and also to its property of reproducing perfectly any surface or shape, would appear to be more suitable material.

A very reliable plaster is known as "Italian fine." This material can be controlled at will. By the addition of a little alum in the form of a saturated solution, it can be made to set in 3 min., whereas a little size-water will retard the setting for 20 mins., 1 hr. or even 2 hrs. In fact a solution of 1 lb. of glue to 7 qts. of water will retard the plaster for about 12 hrs., and the latter when set will be so hard that it can be turned and polished like stone. The addition of 10% finely pulverized marshmallow has the same effect.

A proprietary brand of plaster just recently placed on the market, when dry, has a compressive strength of 1,700 lbs./in.^{2} (compare with concrete of 8,500 lbs./in.^{2}) after 12 months; a tensile strength of 1,300 lbs./in.^{2} and a Brinell hardness of 35. Here, then, is an ideal material for plate patterns, or for patterns for repetition work. The most suitable consistency for mixed plaster is obtained by adding about 2 lbs. of plaster to 1 pint of water; the best method of mixing is to sprinkle the plaster on the surface of the water.

Scrim is a coarse canvas used for reinforcing plaster, and can be obtained in a variety of meshes—the most suitable being 1/8 in. square and 1/4 in. square; both of these grades have their uses for reinforcing. With the more open mesh the plaster is easily worked in, but on the finer and stronger canvas a brush should always be used, otherwise air pockets between the surface skin and the canvas are sure to appear. Plaster is handled in exactly the same way as for decorative architectural work. AIK (1)

1a. Ferrous

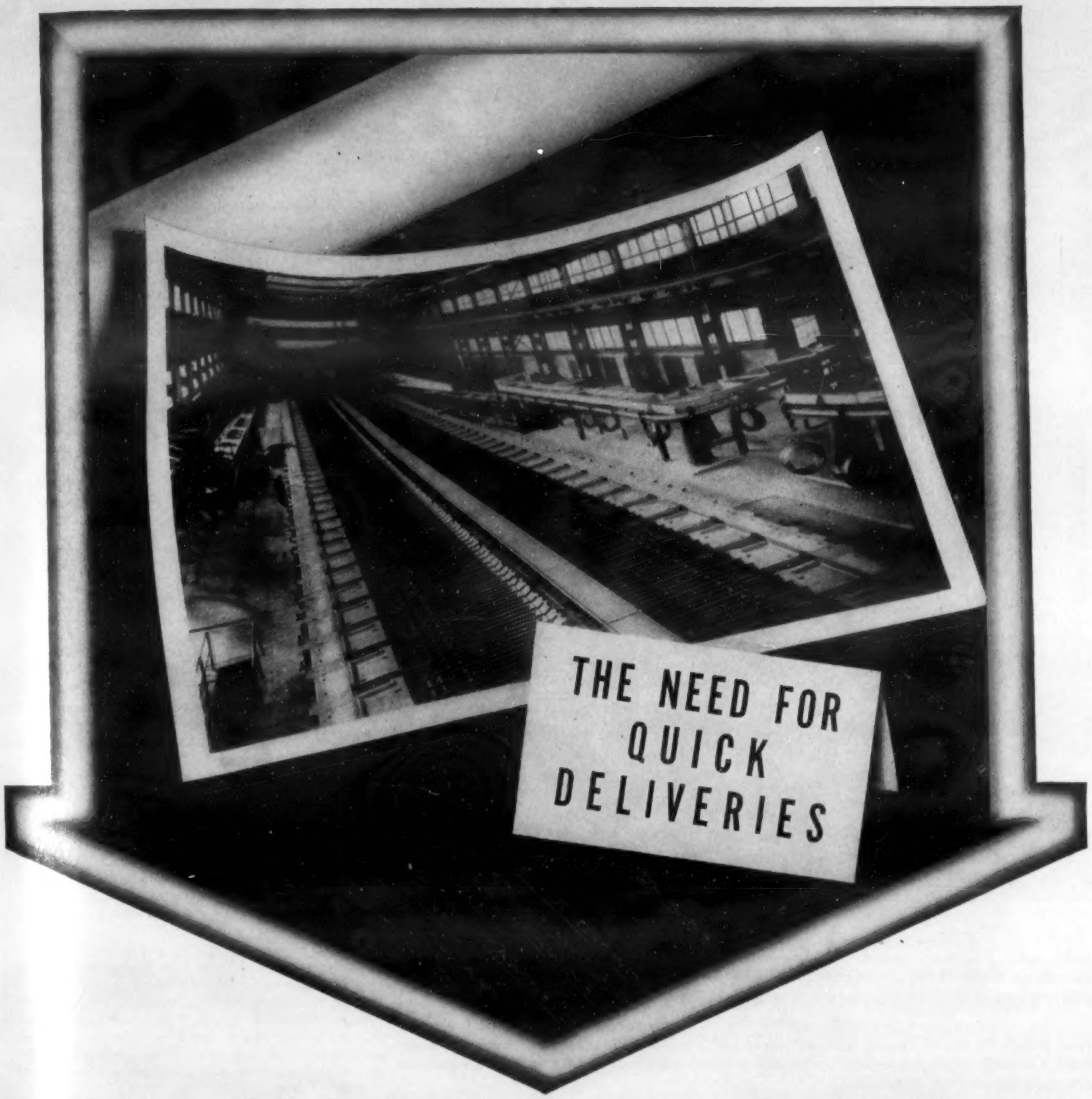
Boosting Blast Furnace Production

"Methods of Increasing Production of Existing Steel Plant Equipment —II. Blast Furnaces." L. E. Riddle (Carnegie-Illinois Steel Corp.) *Iron & Steel Engr.*, Vol. 19, Jan. 1942, pp. 53-57; discussion, pp. 66-69. Practical.

This article [and several others, on open-hearths, Bessemers, billet heating, plate mills, etc. presented in a symposium] is concerned with the attainment of greater production from *existing* plant equipment.

Increased blowing in blast furnace operation has boosted production materially. In the Pittsburgh district, furnaces should be blown with at least 150 ft.^{3} of air/min./ft.^{3} of hearth area, calculated by the carbon method. Under present conditions, the higher coke consumption rates resulting from increase in wind rates will just have to be accepted.

Maximum production requires a stove capacity equivalent to 500 ft.^{2} of heating surface per net ton of rated iron capacity. If this is not available, it can be provided by installing inserts.



ROLLING steel is a *continuous* process, from soaking pits to cooling bed—from reheating furnace to storage bins. Quick deliveries all along the line mean *quicker* deliveries to freight cars—to customers—to profits.

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Both forced draft burners and automatic combustion control contribute to increased heating capacity of stoves. Regular and frequent stack gas analysis is essential.

Air conditioning or dry blast plants that can guarantee the removal of moisture down to 1 grain/ft.^{3} of air, if put on furnaces in the Pittsburgh, Cleveland, Detroit and Chicago districts using natural air, should increase the tonnage 12%.

Increasing the maximum allowable sulphur from 0.030% in hot metal to 0.035 or 0.040 will result in a greater overall production rate in many plants. On the other hand, in certain cases an increase in the sulphur content of the pig iron will cause either an increase in the sulphur content of the steel ultimately made from it, or a decrease in open-hearth production. It thus appears mandatory to investigate the possibility of raising sulphur specifications in the *finished steel*.

One possible source of great improvement in blast furnace production is to provide the furnaces with a lower-sulphur, lower ash, and more uniform coke. In the Pittsburgh district, this can be accomplished by washing all the coal. Elsewhere, coke quality could be improved by coal mixing and bedding.

The use of open-hearth slag is general, but in some plants the high manganese and phosphorus in the iron resulting from its use is objectionable. The increased production of pig iron through the greater use of open-hearth slag should be so balanced that finished steel output does not suffer. Segregating the more desirable tapping open-hearth slag from flush open-hearth slag is important if maximum benefits are to be obtained.

Where undue delays are caused by tapping hole trouble, furnace production can often be increased by the use of remote-control mud guns. The ability of these guns to stop tapping holes without lowering blast pressure results in continuous operation, with consequent regularity and increase in tonnage.

Automatic stock line recorders, automatic control of hot blast and stove dome temperatures, and stove-stack temperature recorders are all necessary for maximum production. Atmospheric humidity recorders have also been used to good advantage to facilitate adjusting the hot blast temperature to the amount of moisture in the blast.

Blast furnace daily production rates per ft.^{3} of hearth area should, for furnaces with Mesabi ore and a scrap-free burden, be equivalent to at least 2.24 net tons where the coke is made from 100% high-volatile coals, and at least 2.45 net tons where low-volatile coals make up more than half of the coal mix. FPP (1a)

THESE two tanks in the plant of Carnegie-Illinois Steel Corp., Duquesne, Pa., were lined with two courses of acid-proof brick laid entirely in Penchlor Acid-Proof Cement.* They are used for pickling steel bars where the mechanical as well as the chemical action is especially severe.

Due to their large size—45′ x 5′ x 4′—both tanks were built with expansion joints in their lining. Inspection after a year's constant use showed absolutely no signs of permanent expansion of the lining. Both bricks and cement are still in perfect condition.

This is typical of the way Penchlor Acid-Proof Cement stands up in tough service. It is inert to all acids except hydrofluoric. It adheres strongly to such materials as brick, steel, glass, carbon, lead, and rubber. Quick-setting and self-hardening, it speeds up acid-proof construction.

For extremely abrasive conditions, or where thermal shocks are extreme, Asplit Cement* provides utmost durability and prevents spalling of bricks. It is a synthetic resin that far outlasts other types of acid-proof construction.

Penn Salt has been engaged for a great many years in the manufacture of acids and alkalies. We have naturally had considerable experience in the use of cements to resist corrosion, and are in a position to give technical advice. We will welcome inquiries on your problems.

***Fully protected by *existing* patents.**

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Water-Cooled Parts of Open Hearths

"PROTECTING WATER-COOLED EQUIPMENT ON OPEN-HEARTH FURNACES." J. B. LUCKIE (E. J. Lavino & Co.) *Steel*, Vol. 110, Jan. 12, 1942, pp. 70, 72, 89. Descriptive.

Heretofore, exposed parts of open-hearth furnace doors have been covered with a low-price clay brick or brickbats. About two years ago, plastic chrome ore began to be used to cover various water-cooled parts in the open-hearth furnace.

It is necessary when applying the ore to a vertical metal surface to employ studs solidly welded to the metal. As one end is cooled, these studs remain rigid and hold the refractory in place, and help to cool it so that there is no excessive erosion from temperature and from dust in the gases.

The length of the studs is about the same as the thickness of the plastic chrome ore, and their diameter and number should be such as to provide enough cooling effect. As the stud oxidizes and wears back, the refractory wears back at about the same rate. The ore should be rammed solidly with hard blows to eliminate all voids, and dried out.

Instead of studs, some plants are welding a nut to the plate and screwing a bolt or threaded rod into place with some added graphite paste. When the lining needs replacing, the bolt is unscrewed and replaced with a new one. This arrangement seems to be satisfactory, provided the bolts are not eroded too much.

In most doors, clay brick will last 10-30 heats and a door lining will cost $5 to $10, depending upon the size of the door and the material used. A plastic chrome ore lining, including studding, will cost $40 to $70 per door, but its life will be 150-250 heats.

Other cooling media, such as bridge walls, ports, door-frames, and bulk heads, have been lined with this refractory. While, on the whole, it is desirable to cover all water-cooling media for better furnace efficiency, it is difficult to state just what economy there is in this new development in trying to cover all such media.

In doors and bulkheads, a direct comparison of refractories can be made, but with ports, door-frames and skewbacks, which are usually exposed to the flame, it

MORE MAGNEFER FOR MORE STEEL

Rotary kilns in which Magnefer is clinkered at 2800°—3000° F.

Unloading sealed container of Magnefer on the open hearth floor.

● **Day and night, the blasting, crushing and burning of dolomite goes on, to make more Magnefer to produce more steel.**

New primary crushing equipment that increases our raw dolomite capacity by 50% has been installed. A large reserve stock of crushed rock has been established. Preparation and burning plants, no longer immediately dependent on primary crushing, now operate steadily at maximum rates to turn out more of the refractories that steel must have.

With production of Magnefer and other prepared refractories at the all-time high, laboratory controls of manufacture are strictly maintained; in fact, are being steadily improved. Uniformity of product is closely guarded and desirable properties embodied to make each material do a particular, efficient job in the furnace.

Dependable refractory service by Basic Refractories, Inc., is helping produce more steel and better steel for America's tremendously expanded Victory program.

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can be proved worthwhile only if the furnace seems to work better, and there are less renewals of the cooling units. It is hoped to learn more about the proper size and spacing of the studs and the best thickness of the plastic chrome ore.

MS (1a)

Centrifugal Casting of Guns

"Casting Guns Centrifugally at Watertown." R. W. Case (Watertown Arsenal) *Foundry*, Vol. 70, Feb. 1942, pp. 62-63, 154-156. Descriptive.

Watertown Arsenal has been making guns for the past 125 yrs.; it was through research at Watertown that the original changeover from cast iron to forged steel was effected.

The return to casting, using the centrifugal steel-casting method, has speeded up gun making, for a single machine will turn out several gun tubes in the time it takes to forge one. Guns cast by this process include 37 mm., 40 mm., 90 mm., 105 mm. and the new model 3 in. guns.

The melting furnaces range in size, and hold exactly the amount of steel needed for each size and type of gun. The molding machine is a horizontal cast tube weighing from 5 to 10 tons and rotated at a high rate of speed. Into this are fitted the molds, bored out to the exact exterior dimensions of the type of gun to be cast, due allowances being made for shrinkage, cold working, etc.

The entire furnace is moved to the molding machine. The pouring box, with nipple, is placed between the furnace and the closed end of the coating machine, with the nipple protruding through the opening in the cover of the casting tube. The charges poured range from 450 to 5000 lbs.

Molds and pouring boxes are preheated. As soon as the casting cools, it is buried in cinders until cold. Then it is normalized in an oil-fired car-bottom furnace, after which it is air cooled. After the heat treatment, it is given a differential quench in water.

In casting, the weight of the metal plus centrifugal force throws all slag and inclusions into the center. Thus, all dirty steel is eliminated when the gun is bored. Machine used for boring simultaneously machines the exterior surface as well.

The lathes used have twin headstock and tailstocks so that two guns can be bored simultaneously. Another saving is the cutting of the rifling directly into the bore instead of inserting a separate liner.

Cold working is done by placing the gun within a cast steel container and pressing it from the inside by hydraulic pressure. By applying high pressure, the diameter of the bore of the gun is increased and the elastic limit is nearly doubled. This cold working also allows an increase of nearly 100% in powder charge and projectile weight.

Examination for defects is made by metallographic inspection and then with X-rays for thinner sections. Radium is used for thicker pieces. VSP (1a)

Molding of Electric Steel Castings

"Moulding Problems in the Electric Steel Foundry." E. J. Kelly. *Foundry Trade J.*, Vol. 66, Jan. 1, 1942, pp. 3-6. Practical.

The data presented in this article relate particularly to work done in the jobbing foundry. The molding methods and materials used must vary widely, and include green sand, skin-dried, and dry sand molds, etc.

Sands used in the steel foundry are of a coarser grain size than would be suitable for iron or non-ferrous work. Ramming therefore, has to be much firmer in order to obtain a good impression on the job to be cast. Oil sand is advantageous for parts that are likely to give trouble, such as ramming-up pegs and blocks.

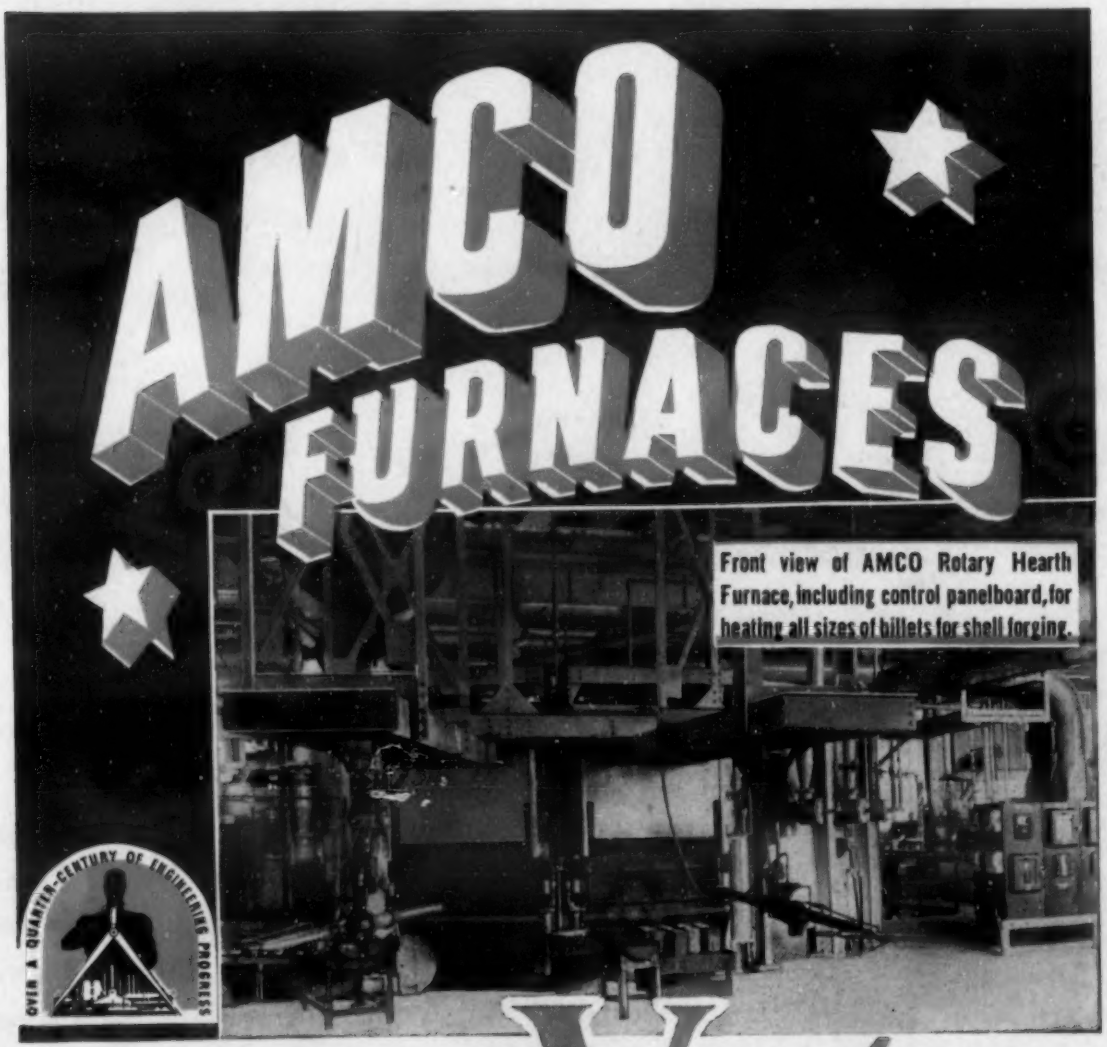
Green sand molding is employed chiefly on jobs that do not require much machining or on intricate work to assist contraction. Jobs weighing up to 1200 lbs., are cast by this method, while many types of castings up to 1 ton could be so made.

Green sand molds are not susceptible to distortion, as is the case with dry sand molds, and if for any reason the pattern has to be replaced in the mold, it may be done without difficulty, and without damaging the impression. It is the cheapest form of molding.

It is good practice in green sand work to ram up pieces of brick, core or metal on to core-prints, so as to form firm supports for cores.

In the case of studs and chaplets used to support heavy cores, pieces of core, rammed into the mold to form a firm base for such supports, are very useful.

Green sand molds should be poured as soon as possible after closing, particularly if denseners and chills have to be used. Warm cores should not be placed in a green sand mold. Green sand molds not cast on the day of making should be parted and left open, to avoid condensation, and only closed prior to casting.



Front view of AMCO Rotary Hearth Furnace, including control panelboard, for heating all sizes of billets for shell forging.

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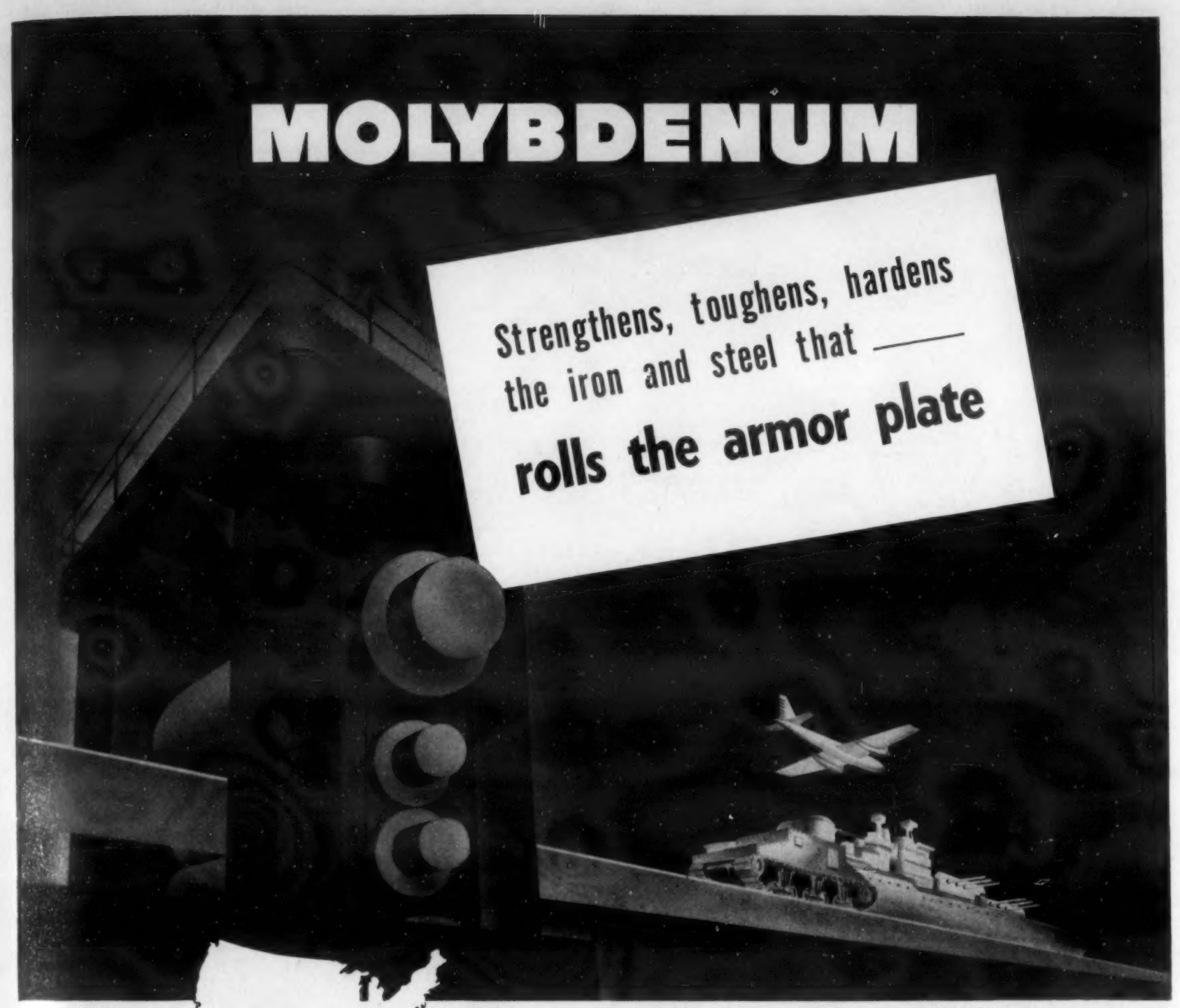

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Dry sand molds are made by the same methods as are used for green sand, but the sand used is stronger, and has a higher moisture content. Larger castings can be made. The molds should be thoroughly dried, and as many cores as are conveniently possible should be incorporated in the mold. AIK (1a)

1b. Non-Ferrous

Production of Brass

"Notes on the History, Manufacture and Properties of Wrought Brass." W. Reuben Webster (Bridgeport Brass Co.) *Am. Inst. Mining & Met. Engrs.*, Inst. of Metals Div. Lecture, Feb. 1942 meeting, 19 typewritten pages. Review.

A review of the history of brass manufacture shows that progress over the centuries was painfully slow, but that in "modern times" advances have been rapid and in some cases revolutionary.

Thus, progress in the production of wrought brass was more or less stalemated until in 1916 the low frequency induction melting furnace (Ajax-Wyatt furnace) was introduced. Today some of the new mills being constructed under the armament program will employ such furnaces of 2-250 kw., capable of making castings weighing about 1 ton. Over 90% of all brass made by wrought processes all over the world is melted in these furnaces.

The hot extrusion process for making small sizes of brass rod provides an excellent example of the dependence of progress in one art upon that in another. Prior to the invention of high speed steel around 1910, the hot-extrusion process could be used only for brasses of high zinc content, whose applications were limited. When high speed die steels became available, however, the extrusion machine could be employed on the entire range of copper-zinc alloys, and is today responsible for at least 30% of all brass production.

While the introduction of the electric furnace with the large size of melting unit and closer control of temperatures and mixtures that it made possible materially improved the quality of both rods and tubes, it has revolutionized the brass sheet mill. The latest practice employs bar castings weighing from 600 to 1000 lbs. These necessitate much heavier rolling equipment and mechanical handling methods throughout.

For cold breaking down, rolls 26 in. in diam. by 36 in. long completely equipped with mechanical handling devices actuated by push button and hand lever control are now employed. The large quantities of brass required for small arms and artillery cartridge cases that are capable of being worked hot permits of hot breaking-down, as a consequence of which a reversing universal breaking down mill closely following those used in steel mills represents the latest practice.

On this mill, running down is done on 4-high mills in tandem. Finishing is done on 4-high and 2-high mills according to requirements, most of the handling being done mechanically. Overhauling, after breaking down, is done on a heavy slab miller. With these have come important improvements in annealing and pickling facilities as well as in methods of handling from operation to operation.

Many patients have been issued covering devices for continuous casting or "direct rolling," some of which have been experimentally successful and 2 at least commercially so. One of the latter developed in Europe has been in use here for several years.

By this method, molten metal is poured continuously into the upper end of a vertical tubular mold surrounded by a water jacket. The metal solidifies in this mold and is drawn continuously thererrom in a solid bar by pinch rolls. A saw traveling with the casting cuts it into appropriate lengths.

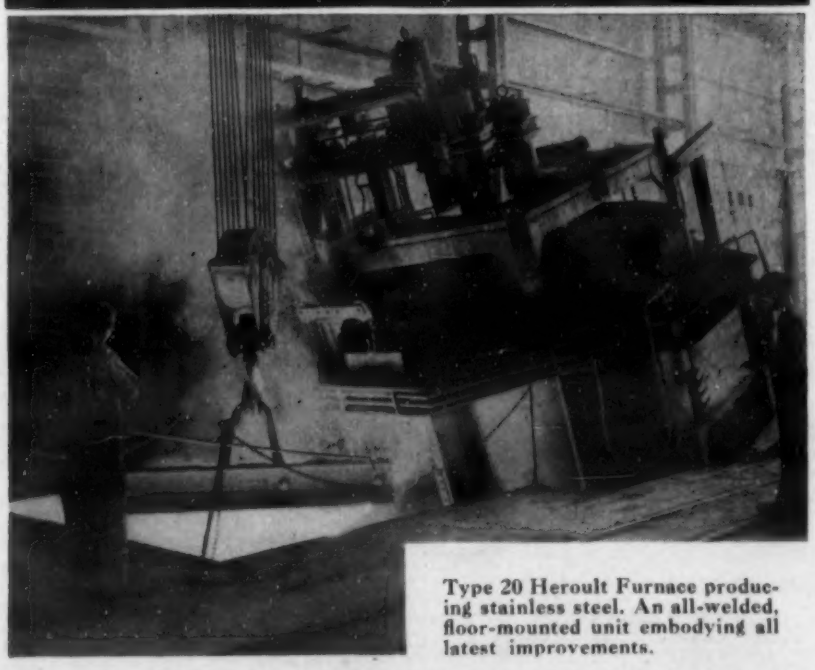
This machine, as far as its use in this country is concerned, has been confined to casting round billets for the extrusion process, but under the armament program will be used for the casting of sheet bars also. The process is as revolutionary in its nature as was that of the electric furnace. It is destined to come into extensive use in one form or another.

The total quantity of brass manufactured follows quite closely the production of steel ingot and is roughly proportionate to it, being normally about 18 lbs. per ton of the latter. Owing to the large amount of brass required at the present time for small arms and artillery cartridge cases, its production has increased more rapidly than has been the case with steel.

The average monthly production of steel at the present time is 60% greater than for 1939, whereas that of brass has increased by 100%. Moreover, brass mills now building when finished will increase this capacity by 60% or more.

Brass production is classified as sheet (which includes strip), rod, wire and seamless tube, normally amounting to about 44, 34, 7 and 15% of the total, respectively. Most brass mills produce quantities of copper strip, tube and alloys not classified as brass which are not included in these figures. FPP (1b)

Heroult ELECTRIC FURNACES



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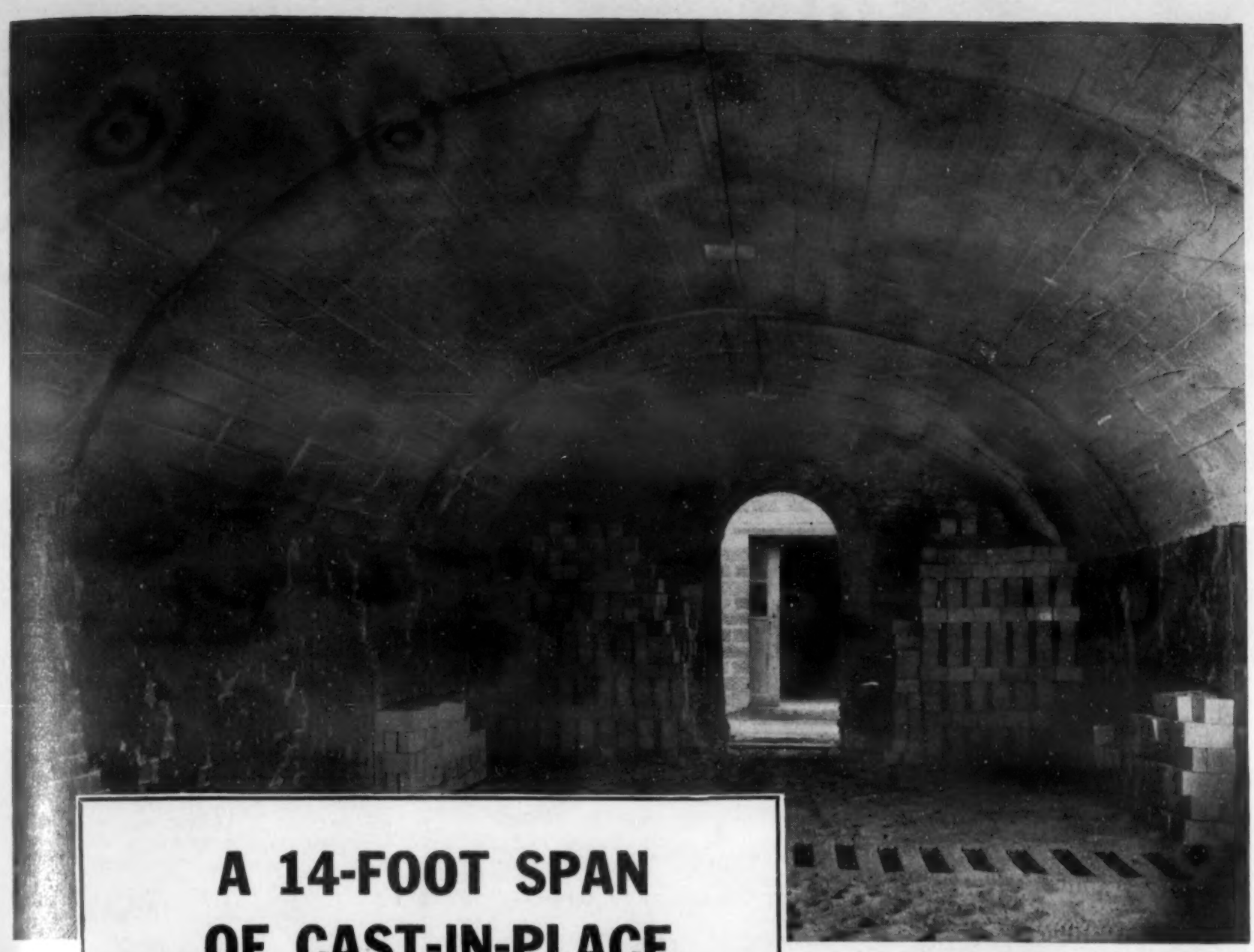

● *Refractory Concrete Roof Arch in end-fired, down-draft kiln. Span 14 ft., length 37 ft., rise 5 ft. thickness at crown 9". Dark lines across arch and along crown are construction joints. Other longitudinal and wavy lines are form marks. Arch had been in service one year when photographed.*

A 14-FOOT SPAN OF CAST-IN-PLACE REFRACTORY CONCRETE

One of several roof arches of Refractory Concrete, made with LUMNITE, used by Eureka Fire Brick Works, Mount Braddock, Pennsylvania, in periodic kilns

EASILY and quickly built, these sprung arches are formed to the exact shape required for structural stability and proper distribution of heat. They keep their shape because there are no small units to work loose and drop into the kiln.

Elimination of joints reduces heat loss and air infiltration to a minimum. The only joints in this 14-ft. by 37-ft. roof arch are the two construction joints at the third points and one lengthwise at the crown.

Refractory Concrete to fit the design and conditions of your kiln or furnace can be made with LUMNITE and a suitable refractory aggregate. The aggregate for the Eureka arches was a hard clay grog. Lightweight aggregates are available for Refractory *Insulating* Concrete.

There's no need for special shapes or units of different sizes when you use cast-in-place Refractory Concrete. It is formed to fit the job. Size and shape of section is determined only by service requirements. That's what we mean when we say—

"Refractory Concrete is ADAPTABLE."

And most important today—

"Refractory Concrete is AVAILABLE."

You can get LUMNITE from building supply dealers in all parts of the country. Aggregates can either be prepared in your own plant or purchased in all industrial centers.

For more information on Refractory Concrete, write Dept. M, The Atlas LUMNITE Cement Company (United States Steel Corporation Subsidiary), Chrysler Bldg., N.Y.C.

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Purifying Plating Solutions

"PHYSICAL REMOVAL OF IMPURITIES FROM PLATING SOLUTIONS". W. A. HELBIG (Darco Corp.) *Proc. Amer. Electroplaters' Soc.*, 1941, pp. 68-76. Practical.

There are two physical means for purifying plating solutions: filtration for removing insoluble, suspended impurities; and adsorption, for removing colloidal and organic impurities which are capable of being held on an adsorptive surface, such as activated carbon.

The 3 elements entering into the selection of a filter are (1) time allowable for intermittent filtration, (2) filter area required for a filtration rate of 25 to 50 gals./hr./ft.^{2} and for a filter cake thickness not over one inch; and (3) solids capacity necessary.

For calculating solids capacity, an approximate rule is that 1 lb./ft.^{2} of either filter aid or activated carbon will give a ½ in. cake. If a slimy, clogging type of solid is to be filtered, a suspension of filter aid in the solution and a filter aid pre-coat on the filter will probably be necessary. A 1/16 in. pre-coat cake is usually satisfactory.

The usual dosage for periodic activated carbon treatment is 3-10 lbs./100 gals. The suspension should be agitated 30-45 min. before filtration. Activated carbon must be added in an auxiliary tank and should not come in contact with the plating tank.

For continuous filtration with activated carbon, 1-2 lbs. per 100 gals. are used. Since brighteners and wetting agents are partially removed by activated carbon, their concentration in the bath must initially be higher than normal, so that the normal concentration is obtained when adsorption equilibrium is reached. VAL. (2)

Paint Drying Ovens

"THE CONTROL OF RADIANT ENERGY IN PAINT DRYING OVENS". ROBERT WYSOCKI (Forbes Varnish Co.) *Metal Finishing*, Vol. 39, Dec. 1941, pp. 704-705. Practical.

Radiant heat drying ovens usually consist of 3 sections, or zones, each having a specific purpose.

The first section, which serves to evaporate residual solvent, employs a gentle heat, with an energy density of 1.5 to 2.5 watts/in.^{2} The actual energy density required depends on the kind of finish and solvent and on the mass of painted work.

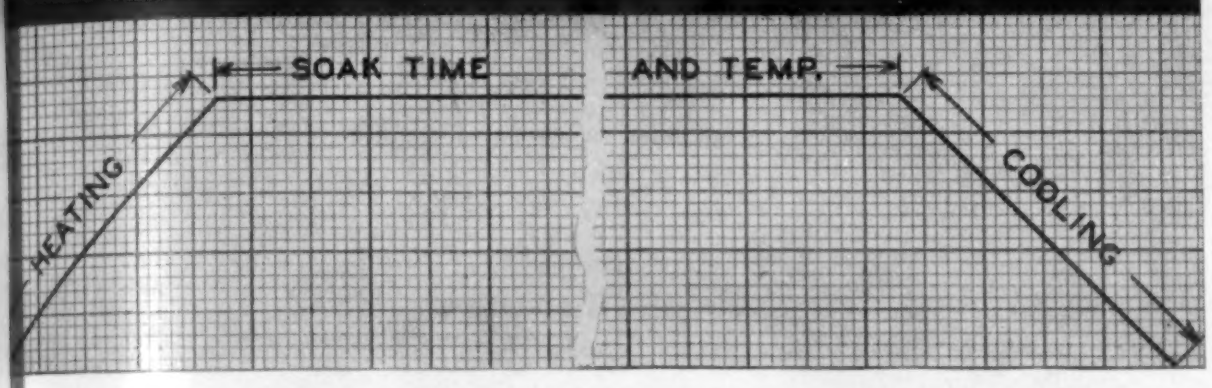
Too high a temperature in the first zone will result in a blistered, spongy film. If the finish is one that dries by evaporation alone, *e.g.*, a nitrocellulose lacquer, this first zone is the only one necessary. If the finish dries by polymerization or oxidation, or both, further baking is necessary.

The second zone employs an energy density of 2 to 4 watts/in.^{2} or more, and serves to heat the work rapidly to the proper curing temperature. The third zone requires 2 to 3 watts/in.^{2}, a lower energy density than the second, since only enough heat is required to maintain the temperature produced in the second zone.

The variable energy densities in the different zones may be secured by varying lamp spacings, lamp wattages, by rheostat current control, or by a series-parallel system of wiring.

Convection currents produce a temperature difference between the top and bottom of the oven. This is overcome by spacing lamps 15% to 25% closer at the bottom of the oven.

In addition to the foregoing require-



Program Control Panel of Micromax Pyrometers. It regulates the annealing, in Wilson cover furnaces, of steel strip and wire for such things as cartridge clips, rifle springs, mask parts and quantities of other defense items. In starting a batch, a controller first uses on-off valve motion, in response to temperature of furnace tube; then it shifts to throttling (proportional position and floating) control, based on work temperature. The rate of heating, the rate of cooling, and the time of soaking, are automatically held as set, unless user switches off these features.

WANT TO "BEND" A TEMPERATURE For Better Heating of War's Matériel?

Program Control is one of the newer ideas now drafted by war industries to help secure the fast, accurate, automatic heat-treatment required by so much war matériel.

Program Control is an improvement over the usual control, which considers only the maximum or soak temperature; because Program Control regulates the rates of heating and cooling, as well as the maximum. The record on the pyrometer chart rises at any desired rate, "bends" at the desired soak temperature, holds the soak as long as is specified, and then "bends" down again into a controlled cooling cycle, to complete the program which will best fit the product for war's needs.

In this strenuous "temperature-bending", various Micromax characteristics are important, but possibly the most useful one is its "micro"-responsiveness. Micromax acts with superior speed-plus-precision on the *small* fluctuations of temperature. Even before these fluctuations are big enough to show on the chart—therefore, even before the best furnace operator could act—the Micromax acts. This micro-responsive handling of tiny changes heads off the big swings—throttles them so that they never develop. Micromax holds temperature with the steadiness needed for uniformity of product.

Micromax Program Control uses standard instruments, grouped at our plant to meet the individual need. If you have a problem along such lines, we'll be glad to try to help in its solution.

Jrl Ad ENT-0600C(44)

Micromax Pyrometers Are Centralized At Rock Island

Practically all heat-treating processes in the Rock Island Arsenal are provided with the latest type of automatic control, no expense having been spared to assure a close check on heat-treating operations. There are appproximately fifty Micromax potentiometer controls, supplied by the Leeds & Northrup

Above: Some of the Micromax Pyrometers controlling Rock Island's heat-treats.

Below: A battery of older L&N Controlling Pyrometers still working dependably and accurately.

Company. Armor plate and forging furnaces are equipped with a Micromax Rayotube and a Micromax electric proportioning control, and there is a large stress-relieving furnace in the Welding Shop which is supplied with a Micromax electric proportioning control.

Reprinted from "Machinery"

Thanks, "Anon"

To the several hundred men, most of them anonymous, who recently helped us with a questionnaire, we take this way of expressing our sincere thanks. These gentlemen received cards which they were asked to fill in and return unsigned, ballot-wise, regarding one of our advertising messages, and we're very grateful for their help.

We asked nothing about the merits of L&N products, and for that reason especially appreciate the correspondents who went far out of their way to give us a back-pat. "One of the greatest wonders in the steel mill today is L&N instruments" says one user. And one of the biggest furnace manufacturers says "Don't know how you could improve on (Micromax) instruments—they are 'tops'."

"All our instrument men" keynotes one good friend "believe L&N are the best pyrometers." And another says "I like your instruments because you make them so easy for glance reading." And so on, far beyond the limits of the space at our disposal.

Thanks again, friends.

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ments, the oven must be so designed that the energy density is uniform in the plane of the work. This may be accomplished by proper choice of reflectors and lamp arrangement. Each application of an oven requires careful consideration of all factors involved. VAL (2)

Chromium Plating

"Chromium Plating." George Dubpernell (United Chromium, Inc.) *Trans. Electrochem. Soc.*, Vol. 80, 1941; Preprint No. 24, 25 pp. Review.

Electrodeposited chromium has unique and valuable properties, such as high hardness (400-1200 Brinell), the lowest coefficient of friction of any structural metal (0.12), and resistance to tarnish, corrosion, heat, and wear.

The only necessary constituents of chromium plating baths are chromic acid and one or more acid catalyst radicals, such as sulphate or fluoride. Sulphate is usually used, added as sulphuric acid or as sodium sulphate. Two typical formulas for chromium plating baths are:

No. 1 Chromic acid (CrO_3); 53 oz./gal.; sulphate (SO_4), 0.53 oz./gal.
No. 2 Chromic acid (CrO_3), 33 oz./gal.; sulphate (SO_4), 0.33 oz./gal.

The ratio by weight of the two constituents should preferably be 100:1, and must be within the limits 50:1 and 250.1.

Chromium baths have a low throwing power, which can be largely overcome by use of special auxiliary anodes. Bright plates can be obtained by properly coordinating temperature and current density within certain limits, taking account of the bath concentration. Thus, bath No. 2, above, at 104° F. requires a current density between 50 and 144 amps./ft.^{2} Maximum deposition speed is about 0.001 in./hr. Small amounts of many metallic compounds are tolerated.

Control tests, such as a bent cathode test, may be used to determine the acid catalyst ratio. Chromic acid, trivalent chromium, and sulphate, are determined by chemical analysis. (Full directions are given.)

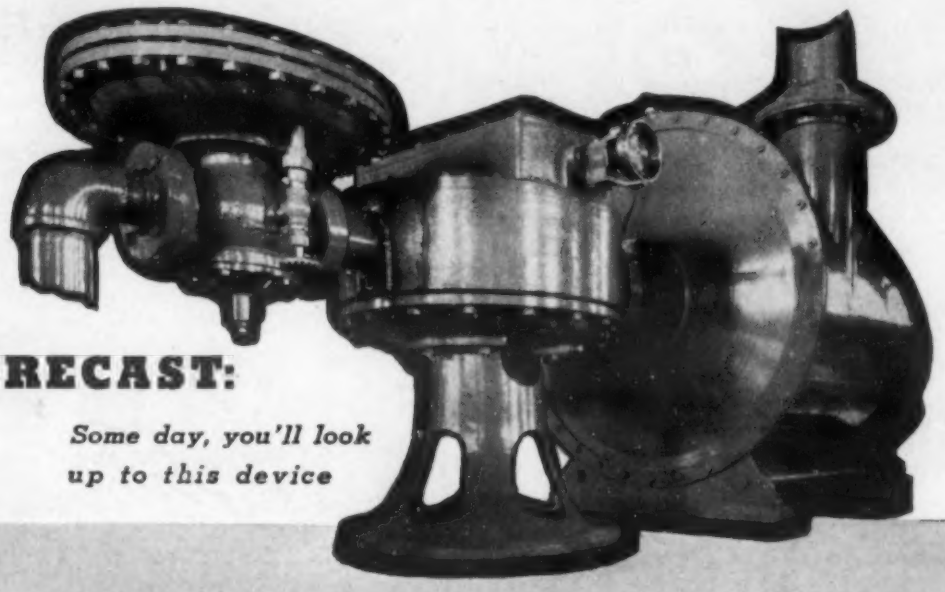
Anode materials, in decreasing order of suitability, are: lead-tin alloy, antimonial lead, pure lead, and iron. Antimonial lead has been commonly used for tank linings, but tin-lead or acid-proof brick linings are superior. Adequate exhaust facilities are necessary because of the chromic acid spray given off.

Successful chromium plating barrels have been developed.

The work is usually cleaned by ordinary cleaning procedures, for which full directions are given. The extraordinarily good adherence required of heavy coatings for industrial uses may be obtained on steel by anodic etching of the steel for 1 min. at 6 volts in 50° Bé sulphuric acid at room temperature. High carbon cast iron and steels may require sandblasting or some other method of cleaning. Zinc and zinc-base die-castings are usually chromium-plated after nickel-plating or copper-and-nickel-plating.

Decorative coatings are 0.00001-0.00002 in. thick. Thickness is tested by stripping or by a spot test, in which the rate of solution of the coating in hydrochloric acid is measured.

Successful industrial uses include plating of gages, taps, reamers, drills, saws, molds for plastics and rubber, various types of dies, pump shafts, and cylinders of internal combustion engines. Gun barrels, *e.g.*, of anti-aircraft guns, are plated for maintenance of accuracy over a long period of use. VAL (2)



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KEMP of BALTIMORE

2a. Ferrous

"One-Shot" Shell Forging

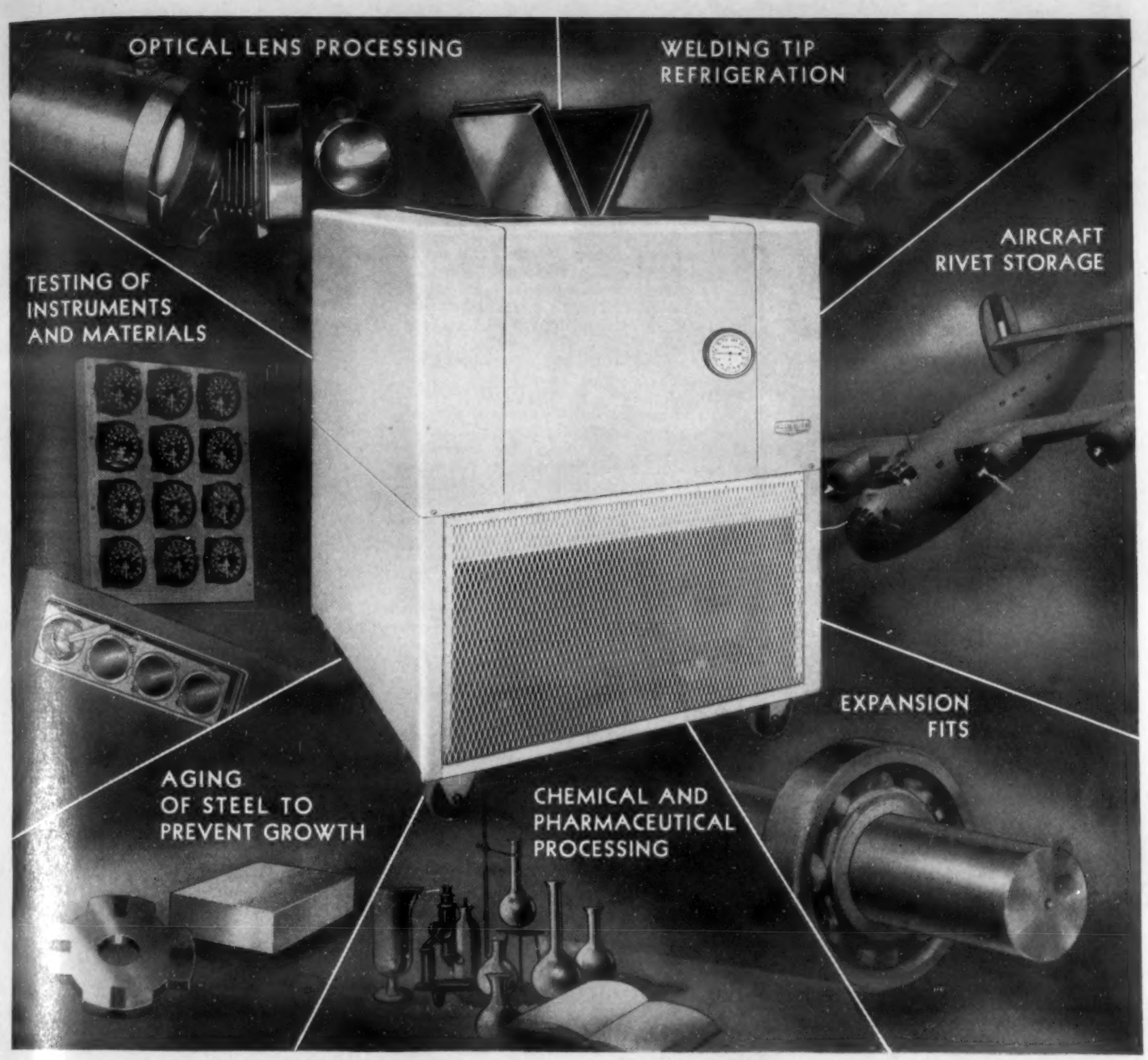
"'One-Shot' Method of Forging Shells." W. P. Muir (Dominion Engineering Co.) *Iron Age*, Vol. 149, Feb. 26, 1942, pp. 43-46. Descriptive.

In this new method of forging shells, developed by Dominion Engineering Co., the first requirement is a stiff press. Next in importance is the position of the billet in the die. The billet must be correctly centered when the punch starts to pierce, in order to obtain a concentric forging.

In the Canadian press, a split die is used that is square with flat corners. This is the first method of piercing in which the metal is pushed ahead of the punch without extrusion, and is at all times in intimate contact with the punch.

The machine is a down stroking, side housing type of hydraulic press. The dies are closed about the top and bottom guides by hydraulically actuated wedges. The punch descends through the top guide, which is firmly held in the intermediate platen and also by the dies.

During forging the dies also close around a bottom guide containing a resistance pin, which forms the base of the die. The pin is backed up by a hydraulic ram in the base, and controls the forging. It is used to support the billet as the dies close and



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during the initial piercing until the top of the billet has been expanded by the punch into frictional contact with the die walls, after which it recedes and thus permits lengthening of the forging ahead of the punch. The valves are all automatic.

The base thickness can be controlled within 1/32 in. either way, although a tolerance of 1/10 in. is allowed. By forming the top of the base pin, any shape of base can be had. The base pin need not be the full size of the parallel part of the die, and the die can be shaped to forge the boat-tail end of a streamlined shell.

As the press is brought down on the mechanically fixed stops, the relationship of the forged shape to the outside cavity shape and depth is exact and can be controlled. The actual forging pressures used have been greatly reduced.

Concentricity is excellent and the cavity finish obtained is satisfactory. If the tools are run too long, roughness will be encountered, and the cavity may have to be ground or hand finished. No machine work is required if the tip is examined periodically.

By virtue of the low pressures used, low alloy cast iron punch tips and die liners are used. The punch tips are redressed every 35-50 shells, and their total life is from 250 to 400 forgings.

The lubrication used is powdered coal or petroleum coke. Punches are cooled by a quenching oil spray after forging. The overall tool cost is about 9.5c per shell. VSP (2a)

Case Hardening by "Dry Cyaniding"

"Nicarb Process of Case Hardening." J. F. Wyzalek & M. H. Folkner (Hyatt Bearings Div.) *Heat Treating & Forging*, Vol. 28, Jan. 1942, pp. 39-42, Feb. 1942, pp. 89-90, 93. Descriptive.

The Nicarb process is a method of heat treating ferrous parts at about 1375°-1600° F. in an atmosphere of ammonia and hydrocarbon gas, so that carburizing and nitriding occur simultaneously. A hard, wear-resistant surface is obtained with or without resorting to quenching.

The character of the resulting case is similar to that obtained with cyaniding. The process offers a means of rapid case-hardening with a case harder than conventionally carburized surfaces and comparing favorably with a cyanide case. It can be used on virtually any grade of steel and on steel castings, cast iron and malleable iron.

The case produced is tough, hard, resistant to corrosion and oxidation, and bonded strongly with the core, and shows virtually no tendency toward exfoliation. Distortion of parts is minimized appreciably, especially where they are slowly cooled in the treating atmosphere.

One typical installation is a gas-fired, continuous, muffle-type furnace with woven-wire belt, used for hardening bearing parts of S.A.E. 1010 or 1015 steel. As the parts enter the furnace, they are heated quickly to about 1600° F., then immediately cooled uniformly to about 1300° F. at the end of the effective chamber and to about 300° F. in the muffle extension before dropping through a water-sealed chute into a discharge tank. For additional ductility, the maximum temperature in initial heating is lowered to 1560° F.

With a gas mixture of 9 parts ammonia and 1 part propane, a file-hard surface is obtained. Using a total gas flow of 82 ft.^{3}/hr., a 14-min. cycle produces a case depth of 0.001-0.003 in., a 24-min. cycle of 0.003-0.005 in., and a 75-min. cycle of 0.008-0.12 in. Parts that would readily distort even when oil quenched from salt-baths are produced with negligible distortion. No washing is required.

Microscopic examination indicates that the Nicarb case has an outer rim containing more nitrogen than the cyanided case, as the former contains nitride needles which are absent in the latter. However, the cyanided case tends to contain slightly higher percentage of carbon.

Another type of furnace used is a gas-fired, continuous, tray-type, muffle furnace, operated by a mechanical pusher. It is provided with oil-quenching facilities, which permit greater surface and depth of hardness in the Nicarb case and higher core hardness.

Generally, 2 types of work are treated in this furnace—one being split-type races and snap rings of S.A.E. 1060 steel. These are hardened to the required hardness and microstructure and, to counteract mill decarburization of the raw material, Nicarbed a slight amount at the surface by treating in 16 ft.^{3} of ammonia and 26 ft.^{3} of propane/hr. for a cycle of 45-75 min., depending upon their size.

The other type of work consists of rings of S.A.E. 1015 steel, which are Nicarbed to a minimum depth of 0.035 in. by 77 ft.^{3} of ammonia and 32 ft.^{3} of propane/hr. and a 4-hr. cycle. Parts are heated to 1590° F. and quenched in oil.

A reciprocating hearth furnace is used for treating chuck bodies, sleeves, nuts, jaws, and bevel gear wrenches made from S.A.E. 1315, 1340, 3140 and 4615 steels. A case depth of 0.006-0.008 in. is produced by an atmosphere of city gas and ammonia. Most of the parts are first carburized, slowly-cooled, and machined prior to Nicarbing and quenching.

Other types of furnaces used are the rotating retort-type batch, bell-type batch, and rotating retort continuous-type furnaces. They generally use an atmosphere of 1 part city gas and 2 parts ammonia in treating S.A.E. 1020, 1045 and 4140 steels MS (2a)

Flame Hardening Practice

"Flat Surface Hardening." J. G. Magrath (Air Reduction) *Am. Machinist*, Vol. 85, Dec. 10, 1941, pp. 1260-1263; "Cylindrical Surface Hardening," *Ibid.*, Dec. 24, 1941, pp. 1317-1319; "Spinning Methods," *Ibid.*, Vol. 86, Jan. 8, 1942, pp. 8-11. Practical. For previous instalments, see Metals and Alloys, Vol. 13, Nov. 1941, p. 762; Vol. 15, Jan. 1942, p. 148.

The spot method of flame hardening is simplest since the zone to be hardened is heated above the critical temperature; the torch is removed, and the article quenched. The method is often made completely automatic if production warrants.

If the area to be hardened is larger (for example a rail end), one or more torches are moved back and forth over the part until the required temperature has been reached. The flame is then extinguished or removed, and the entire unit area quenched.

In the flat progressive method, either the work or torch may move; the speed depends on the depth of hardness required and the dimensions of the workpiece. Mechanical control must be satisfactory to get good results. If several passes are required, it is frequently desirable to allow 1/8 in. between passes to prevent softening the already-hardened portion.

1. WHAT IS THE SUPER-CYCLONE FURNACE?

It is a further development of the Lindberg Cyclone furnace utilizing 100% forced convection heating with temperatures to 1750° F.

2. HOW WILL THE SUPER-CYCLONE HELP ME?

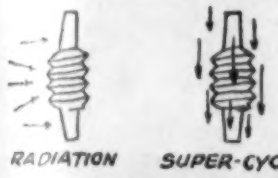
It all depends on the type of work to be done. Among the operations being handled by well over 100 Super-Cyclone installations already in service are: tempering, annealing, hardening, normalizing, and nitriding. Because the work can be preheated at any desired rate and cooled according to a definite schedule, the Super-Cyclone is well suited to stress relieving, spheroidizing, malleablizing, and other special heating operations requiring a definite cycle.

3. CAN THE SUPER-CYCLONE BE USED FOR LOW TEMPERATURES?

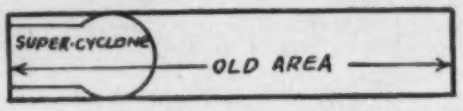
Yes. The temperature range of the Super-Cyclone is 250° F. to 1750° F. with equal heating and control accuracy within the range. This feature of the Super-Cyclone gives you a tempering, hardening, annealing, and normalizing furnace all in one and makes it a flexible unit for the small or medium heat treating department, as well as a heavy production unit for the large shop when put to work on one type of job.

4. HOW DOES THE SUPER-CYCLONE KEEP WORK STRAIGHT?

By eliminating "one-sided" heat. The work is piled up or stacked up in the work chamber, either on itself or on a fixture, and the heat is driven through it at a high velocity, heating each part thoroughly and accurately. The 100% forced convection heating principle prevents radiant heat of a source hotter than the desired work temperature from striking the charge and causing distortion. This proved itself in handling 20 pound worm gears. When hardened from box furnaces 85% went out between .015" to .025". Straightening took 8 hours per 100 worms. When hardened from the Super-Cyclone, 90% required no straightening whatsoever, and the balance were out a maximum of .010". Straightening time: 30 minutes. A reduction of 7½ hours straightening time per 100 worms.



5. HOW ABOUT FLOOR SPACE?



As a general rule, based on what the Super-Cyclone has done in other plants, you can figure that this furnace will require only ⅓ the floor space of any other type of equipment to handle the same or increased production. At a large midwestern plant annealing grey iron castings, one Super-Cyclone using but 1/6 the floor area, replaced 8 radiation type box furnaces *and turned out twice as much work!* It would take 7 box furnaces and 7 men to approximate the production of the Super-Cyclone shown on the opposite page. Another manufacturer, hardening worm gears found that one Super-Cyclone did the work of 3 box type furnaces occupying 3 times the floor space.

6. HOW ARE PRODUCTION POSSIBILITIES FIGURED?

You can roughly check the production increases possible through the Super-Cyclone, by spreading parts to be heated on the floor, one layer thick, as laid out in a radiation heated furnace. Then take those same parts and stack them up in a 36" circle, 4' high, making allowance for spacers or supports. Figure it will take a maximum of 3 hours to heat the stacked up parts on a fixture and 5 minutes to quench the lot. Ordinarily you will find production increases of 200% to 1000% possible. The parts remain on the fixture for quenching and tempering, a substantial saving in handling.

7. DOES THE NAME SUPER-CYCLONE MEAN THAT IT IS A LARGE FURNACE?

No. A standard size Super-Cyclone is made with a chamber dimension as small as 16" diameter x 20" deep. The name Super-Cyclone denotes the ability of the furnace to increase production and keep work straighter by using 100% forced convection heating with temperatures from 250° F. to 1750° F.

THE name "SUPER-CYCLONE," like Topsy, just grew. During its infancy on the drawing boards, the engineers planning its potentialities, called it the "Super" Cyclone. Then came its adolescence in the shop where the boys referred to it as the "Super." When troubles developed, the service men called it something else. But whether it was affection, anticipation, or just the lack of a better name, most everyone called it the "Super."

In the advertising department we got excited at the prospect of creating a name for the new product . . . a name that would go down through the ages with Buick, Bon Ami, Aunt Jemima, Carter's Little Liver Pills, and many others. We burned the midnight oil with creative fervor . . . "Little Demon Heat Treater" . . . "The Chinooker" . . . "The Senator" (100% forced convection hot air) . . . "Breath of Sahara" . . . and other names, equally as inadequate, were conceived. Each new appellation was referred to as a name for the "Super" and before we knew it, *we were calling it the "Super" too!* When the time came to announce it to the trade, for want of a better name, we had to release it as the Super-Cyclone. We knew then, that we were but pawns in the hand of Fate. Our dream, of launching and christening this new furnace with a bottle of "7-up" and a few well chosen words, had blown up in our faces. We feared that in letting it be known as the "Super" Cyclone, the general opinion would be that our advertising department had "gone Hollywood."

Soon, reports on the new installations came in sounding like letters from Bob Ripley . . . and they continue to come. We know now, that this furnace by any other name would be as remarkable. The "Super" has clicked in the field! The advertising department still feels it owes an apology for the name "Super-Cyclone," but its performance is all that the name implies.

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STANDARD SIZES IN WHICH THE SUPER-CYCLONE IS AVAILABLE

Delivery time is speeded considerably when standard size furnaces are selected, rather than special sizes which must be drawn up. Drawings are available for the following sizes of Super-Cyclones all of which have been built and are in operation. Most are gas fired, although a number are available electrically heated.

CHAMBER SIZE

16" diameter x 20" deep
22" diameter x 26" deep
22" diameter x 36" deep
25" diameter x 20" deep
25" diameter x 30" deep
25" diameter x 48" deep
28" diameter x 28" deep
28" diameter x 48" deep
28" diameter x 60" deep
33" diameter x 36" deep
33" diameter x 48" deep
38" diameter x 36" deep
38" diameter x 48" deep
38" diameter x 60" deep
43" diameter x 48" deep
48" diameter x 72" deep
60" diameter x 36" deep
60" diameter x 48" deep
60" diameter x 72" deep

100 SUPER-CYCLONE INSTALLATIONS ALREADY IN SERVICE

IMPORTANT NOTE: Like all other Lindberg developments, the Super-Cyclone has been thoroughly proved under 24-hour a day production conditions for a minimum of 12-months before announcement to the trade. Every effort has been made to restrict the sale of these units until the probationary period was completed. In spite of this, however, many of those who have seen the furnace in operation during the past 18-months have quickly been aware of its production possibilities and requested that units be constructed for them. Thus, over 100-Super-Cyclone installations are in service from coast to coast. One or more of these is near you, as is a Lindberg District Office, staffed by practical and competent sales engineers. The Super-Cyclone is *not* a cure all, nor do we represent it as such. It is speeding production, turning out straighter work, and cutting costs for many firms however, and we will be glad to survey its possibilities for you, on your work, at your request.

FURNACES

HYDRYZING FOR SCALE-FREE AND DECARB-FREE HARDENING

If wide areas of higher carbon or sensitive alloy steels are to be hardened, it is advisable to allow wider soft zones to prevent checking. If these soft zones are objectionable, then side quenching may be necessary to prevent undue tempering of the previously hardened part. Sometimes multiple torches with wide tips can be used to eliminate the necessity for these soft zones.

In circular band progressive hardening used on the outside surfaces of rounds, separate circular bands are hardened. Upon the completion of each, the tip is moved to the next position and fixed after which the object makes one complete circumferential turn past the flames and is quenched.

An 8-in. diam. shaft of 0.33% C, 0.7% Mn 2.9% Ni, 0.1% V, 0.3% Mo was hardened by this method to an average hardened depth of a little over 1/8-in., with a hardness of 500 Brinell over 75% of the hardened depth. A 7½ in. diam. shaft of S.A.E. 1050 steel was hardened 3/16 in., with a hardness of 600 Brinell immediately below the surface and 500 Brinell prevailing over ⅔ of the hardness depth.

The spiral band method has a similar set up, except that the tip moves along the top, parallel to the spindle axis at a speed about equal to the width of the tip, plus 1/8 to ¼ in. or more, per circumferential turn of the object. In both cases, intermediate softened zones are held to a minimum by an overlap quench and shield.

In the spinning method the entire surface to be hardened is heated above the critical by an oxyacetylene torch before the part is quenched. This circular band spinning is particularly suited for round surface hardening where large-scale production warrants the increased investment for equipment.

Since the distribution of heat is even, the depth of hardness is uniform. There are no overlaps or soft zones such as are formed in flame hardening by the spiral or circular band methods.

Circular band spinning may also be employed for inside surfaces. However, in the case of long round objects, progressive spinning is superior to either the circular band or spiral methods; the heating tips and quench ring travel parallel to the axis of the spinning object.

If the object being hardened is thin, it may be necessary to provide a forward cooling jet ring. When hollow objects are being hardened on the outside only, an inside quench may be provided to prevent excessive heat penetration. JZB (2a)

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Machining Cannon Rifling Grooves

"Broaching of Rifling in Cannon." H. F. Safford (Watervliet Arsenal) *Mech. Engineering*, Vol. 64, Feb. 1942, pp. 113-117. Descriptive review.

The various methods of machining the rifling grooves in cannon have been a natural growth over a period of years. These methods vary with the length and diameter of the bore. Since 1918, the Springfield Armory and Rock Island Arsenal have carried on tests, within the limit of funds available, for improving methods of rifling small-arms weapons, and the Watervliet Arsenal, for rifling cannon. At present, all guns below 0.6 in. bore are classified as "small-arms weapons" and all above as "cannon." This discussion is confined primarily to cannon.

Conventional Methods

The two methods that have been standard for years are the single-hook cutter and the multi-tool adjustable rifling head. The former was applied mostly to small arms and to cannon from 0.8 to 1.5 in. bore. The latter was used for all calibers above 1.5 in.

The hook cutter is a pull-type tool mounted in a head the diameter of which is between 0.001 and 0.0005 in. smaller than the minimum bore size. The advantages credited to this type are simplicity of cutter manufacture, and low cost of upkeep. The disadvantages include the length of time required to complete a barrel, the large number of rifling machines required, and the danger of taking cuts too heavy because of the hand feed.

The adjustable cutter head is of the push type known as the Watervliet head and also as the White head. The normal depth of cut is 0.001 to 0.0015 in. until near to full depth of the groove, when the cut is diminished to 0.0005 in. to obtain the final smooth finish.

Cuts finer than 0.0005 in. are to be avoided with any method of rifling, because of the danger of riding over the surface without cutting. When this happens (and it *does* happen), the next pass of the tool takes a double cut which may break the tool or leave an unsatisfactory finish. In the larger cannon, a set of roughing or so-called breakdown cutters is used. This set is followed by a set of finishing cutters.

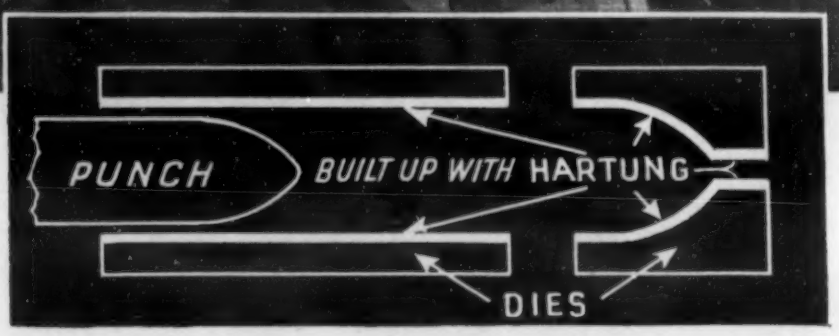
The advantages of the adjustable cutter head are that it has the ability to cut uniform or increasing twist of rifling, change of shape of grooves only requires new cutters, and the cost of cutters is not ex-

HOW P&H "HARTUNG" HELPS MAKE SHELLS

Used to Hard-Surface Forming Dies

IN the forging process used to make shells for these 75 mm., 90 mm., and 105 mm. guns, steel bars are passed through a series of dies to form the outer surface of the shell. A punch or piercing die forms the inner cavity — as shown by sketch at right.

For hard-surfacing these dies, P&H "Hartung" has been extremely successful. After the "build-up" with this tungsten molybdenum electrode, dies are heat-treated at 1250° F. This reduces their hardness to 45-50 Rockwell "C", making the surface machineable with Carboloy tools. The deposited metal, free from pin holes, assures smoother finish, reduces wear and materially increases die life.



P&H "Hartung" is also widely used for building up tool steels. With air hardening properties in excess of 60 Rockwell "C", it maintains a durable cutting edge. It is but one of the complete line of P&H Alloy Electrodes. Write for full information.

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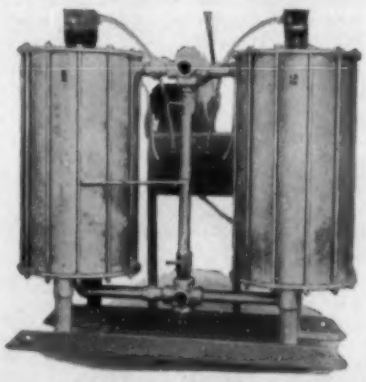

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cessive. The disadvantages are the fact that skilled operators and careful adjustment of cutters in the rifling head are needed; operating time is slow; hand feed is dependent upon skill of operator; and because of the number of passes required, cutters often must be ground, or at least stoned, before one gun can be completed.

Disk Broaching

The disk-broach method is one of the most modern methods now in use. After the 1st World War, the shape of rifling grooves was materially altered in order to improve accuracy life. The old radial grooves were replaced by grooves of much greater depth having straight side walls which were much more difficult to machine. Disk broaches for cutting the new type of rifling were developed at Watervliet.

All disk broaches now manufactured were taken from the Watervliet drawings. The 8-in. size approaches the practical limit for this method of rifling. This method has been thoroughly tested and is positively safe to use provided proper technique is followed.

In disk broaching, the standard type of grooved rifling bar is used, with the rifling head mounted by means of a taper shank. The rifling head is a solid steel body drilled for passage of coolant and with a cast-iron or bronze sleeve for proper bearing surface in the bore of the gun.

The disk cutters are mounted at the front end of the head on a closely fitted pilot and are driven by means of a key inserted in the head. A nut is used to steady the cutter on the head to avoid chatter. In certain guns where the width of the land is narrow and the cutting pressure high, it has been found necessary to insert carbide-bearing strips to prevent cutting or excessive wear of the bearing sleeve.

With the exception of the 20-mm. size, all of the disk broaches are designed to cut all the grooves at once. The broaches are made from solid bars of high-speed steel up to and including 6 in. diam. The 8-in. diam. broaches now being manufactured for test are to be made up of sectors bolted on hardened steel disks.

The number of disks required varies from 28 for the 37-mm. gun to 56 for the 155-mm. gun. The maximum depth of cut is 0.0015 in., and the minimum for finishing, 0.0005 in. All disks are cut to the full width of the groove.

Coolant should be fed under at least 500/in.^{2} pressure. The flow should be directed behind each cutting edge by properly directed holes drilled radially to the center. The coolant is fed through the rifling bar.

One manufacturer feeds coolant both at the front and rear of the cutters. Feeding to the front only is not successful because chips prevent the coolant from penetrating to the cutting edges.

The particular advantages of this method are: Substantial time saving; elimination of requirement for skilled mechanics; practical elimination of the "human element," since the depth of cut is automatically governed; and reduction of the possibility of spoilage. The disadvantages include the necessity of providing fixtures to insure interchangeability of cutters, and the danger of using the wrong cutter.

The Pull-Bar Broach

The most modern development of rifling methods is that of the pull-bar broach. This has been strictly a commercial development with the Watervliet Arsenal lending technical advice and assistance. To date, this method has been tested for bore sizes from 0.22 caliber up to 3 in.

Those which are in actual use, or give most promise of success, are for the 0.50-caliber machine gun, the 20-mm. machine cannon, and the 37-mm. gun. It is the author's personal belief that the practical limit for this method is determined by the bore diameter and length of barrel, and will probably include the 40-mm. gun.

Beyond this size, the disk-broach method appears at present to be most suitable. Above 8-in. gun calibers, the adjustable cutter head is to be preferred. In the 37-mm. setup, one broach is pulled at a time. The broach floats on a frictionless bearing, developing its own twist. A pilot is provided for centering in the bore and for locating in the grooves already cut. There are 8 broaches in the set. Twenty minutes is estimated as the floor-to-floor rifling time, with a tool wear of approximately 100 guns per grind. Material up to 320 Brinell can be broached.

The advantages of this type of broach are the material saving in production time, the saving in the number of machines required, and the saving in floor space. The disadvantages are inability to cut increasing twist rifling, danger of tearing side wall of groove if angle of twist is not correct, and danger of pilot sticking in bore.

None of the methods discussed is new in principle. However, the disk-broaching and pull-bar-broaching methods have been materially improved and modernized. The single-hook cutter with automatic indexing is still widely used, although slower than pull-bar-broaching.

Pull-bar-broaching has yet to stand the test of time, but it should eventually prove to be the most efficient method for bore diameters from 0.5 to 2 in. The practicability of disk broaches has been definitely proved. They are very satisfactory for bore diameters from 1.5 to 6 in. and probably 8 in. The adjustable cutter head is the most satisfactory for bores larger than 8 in. (2a)

Hollow Steel Propeller Blades

"Quality Control of Hollow Steel Blades." H. P. Reiber (Lycoming Div.) *Aviation*, Vol. 41, Mar. 1942, pp. 68-71, 196-197. Descriptive.

Strength-weight ratio is the most important factor in the design of airplane propellers, but "airworthiness" (which depends on such things as profile shape, torsional stiffness, etc.) must also be considered. The demand is for propellers of 10-18 ft. diam., drawn by 800-2,500 h.p. engines.

Hollow steel blades were originally made of laminated sheet. Recently, a solid steel blade—with a unique thin airfoil section resembling a semi-colon, and excess metal bored out of the shank section—has appeared that compares favorably in weight with aluminum alloy blades.

Modern hollow steel blades are of two types—two-piece blades, and single-piece blades formed from tubes. The two-piece blade uses chromium-vanadium (S.A.E. 6130) steel, which is readily amenable to atomic hydrogen welding. The Lycoming or tubular blade is produced from seamless colddrawn tubes of nickel-chromium-molybdenum (S.A.E. X4330) steel.

Two major and conflicting requirements affected the choice of steel: (1) High hardenability (sluggish transformation) is necessary, because the blade must be simultaneously quenched and formed in metal dies, and there is an unavoidable delay between the furnace and the press; (2) before forming, the blade must be resistance-welded and copper-brazed, and the high hardenability requirement introduces some weld-cracking danger. Actually, in the S.A.E. X4330 used, the carbon is held to 0.31% max. and the manganese to 0.30-0.60.

The resistance-welding technique depends on tube thickness. It was found necessary to use long-duty cycles with a burst of current or impulse in each spot. Hardness gradients through the overlapping spots must be absent, since they correspond to stress gradients that can cause cracks.

In the Lycoming process, the condition of the inside surface must be nearly perfect. Scale would seriously affect the quality of the welds, which must be made on an annealed and hot-formed tube. Therefore, whenever the surface is to be heated, the tube is closed and a non-oxidizing gas is forced through gas fittings in the blade.

In the two-piece blade, the camber and thrust plates are first variegated taper milled, die formed cold in a press, placed in a blade shape welding jig, with an internally inserted 3-piece mandrel, then welded around the tip, leading and trailing edges, and shank seam by the atomic-hydrogen method. The blade is then heated and oil quenched and finally drawn. Numerous operations follow such as lathe turning and grinding the shank end, profiling, fitting templates, polishing for balance, checking dimensional tolerances, balancing and chromium plating.

CONTROLLED TEMPERATURE QUENCHING

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Improves Physical Properties of Steel and Increases Production

Manufacturers of heat-treated steel parts have found that in substituting carbon for alloy steel it has been possible to regain high physical properties and avoid rejections by carefully controlling the quenching temperature.

The quenching bath temperature is accurately controlled by the NIAGARA HEAT EXCHANGER which also adds to cooling capacity while saving water consumption. This has given increased production of heat treated parts.

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In the present one-piece Lycoming process, an internally polished and swaged seamless steel tube is used. This is upset and lathe-turned to the correct wall thickness. A diaphragm is welded into the large open end and a pipe connection on the smaller flanged end.

Rust-inhibited water under pressure is maintained in the tube while it is bent to a curvature such that the convex edge will provide a seamless leading edge when subsequent operations develop the circular sections into airfoil shape. While still cold and filled with water, the bent tube is partially flattened.

Next, the circular header on the large end is removed, the water is drained, the tube is sheared and welded, and a forked locator is attached. Then the flattened tube is hot pre-formed to blade shape between hot dies on a hydraulic press, the locator and flange assuring correct register.

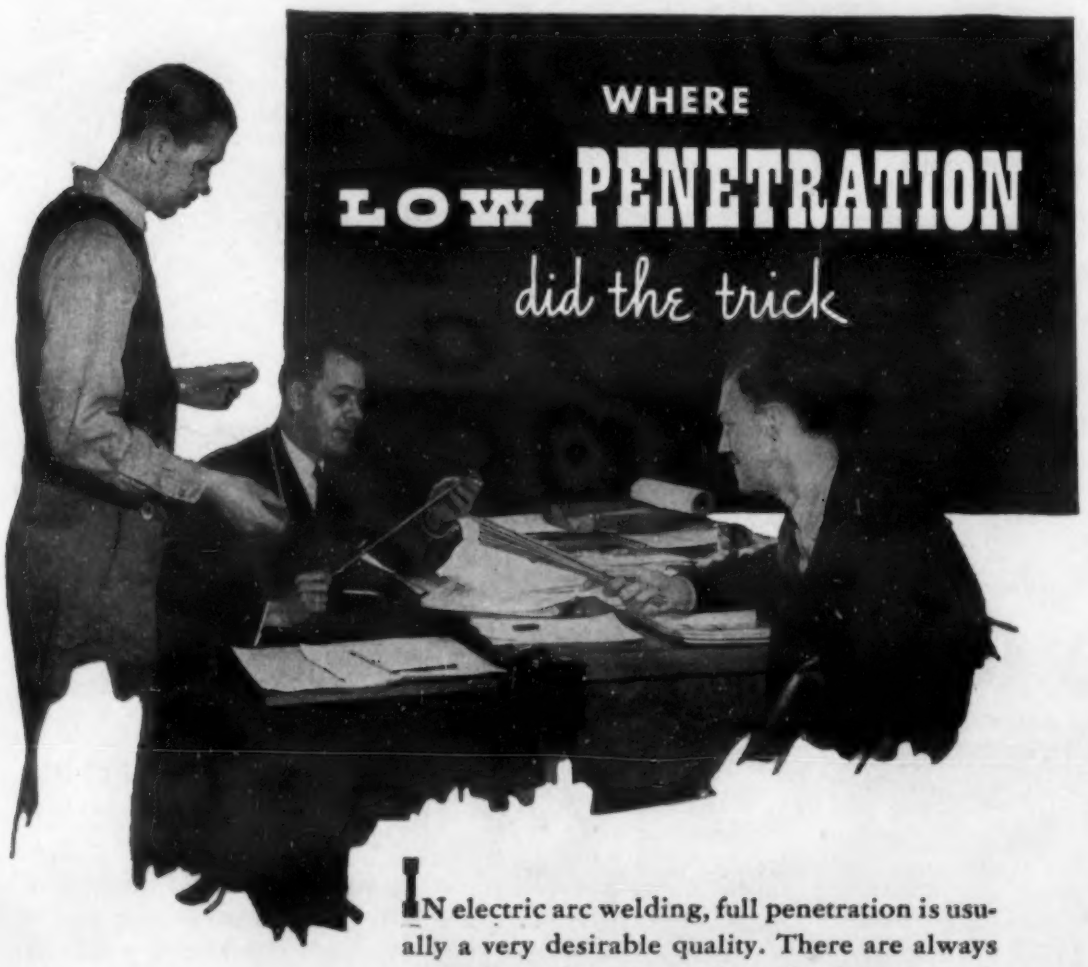
At the proper moment, inert gas under high pressure enters and "inflates" the tube, which in combination with the dies, creates blade shape. The trailing edge, tip and part of the tip section of the leading edge is then resistance seam welded.

The locator and triangular portion of the trailing edge are next removed to a rough approximation of finished planform. Copper wires are inserted through the shank, along the leading and trailing edges of the blade (in a controlled atmosphere furnace). This produces a copper filleted blade, which eliminates stress raisers at the end of the weld.

The welded and brazed blade is heated and registered between cold dies. High pressure inert gas inflates the blade to an exact duplicate of the die cavity in combination with the dies closing operation. The die quench operation previously mentioned, and the subsequent draw or tempering phase, present a blade that satisfies the requirements of heavy service loading.

The blade is finally nitrided in a conventional manner and upon cooling in the presence of some air, there results a durable and corrosion proof dark blue finish. This combination reduces abrasion and eases reflected light from the blades to the pilot's eyes.

The blade is ground on the shank and concentric with a line passing through the center of gravity, following the particular design for blade shank assembly. The blades are finally inspected by the Magnaflux method, and then demagnetized by passing through a demagnetizing coil. They are also inspected by X-ray in a technique that reveals inclusions, cavities and welding and brazing defects, if in existence. (2a)



IN electric arc welding, full penetration is usually a very desirable quality. There are always exceptions that prove the rule, however, although they are not always easily discerned.

For example, a fabricator of light gauge plate was unable to get any more bare wire for welding. The Murex engineer recommended an available coated electrode of a type not widely used in war production. Having relatively low penetrating qualities, the rod did not burn through the light gauge metal. In addition, the coating speeded up welding and improved the appearance of the work.

Manufacturers who are directly or indirectly engaged in war production are invited to call on Murex engineers for advice on welding problems—whether or not they are users of Murex electrodes.

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ARC WELDING ELECTRODES

Flash Welding Aero Engine Mounts

"Mass Production Through Flash Welding." C. J. Hertel. *Welding J.*, Vol. 20, Dec. 1941, pp. 846-849. Descriptive.

One of the main difficulties that has been encountered in the past in the welding of aircraft engine mounts is that the procedure for welding has had to follow predetermined experimental methods. This condition necessitates the use of highly skilled welding personnel, working in small specialized groups, and assigned to definite assemblies.

There is an acute shortage of such highly specialized welders and it is impossible to make the engine mount a mass production item while using the gas- or the arc-welded assembly method on the 97 parts required. The flash weld method developed is applied to a mount made up of only 35 parts, tube ends are flash welded to tubes, and the assembly is completed, using 22 standard bolts.

Only about 2 man-hrs. of semi-skilled man hours are required. Semi-automatic machinery is used for the fabrication of the parts comprising the new mount.

Flash welding is advantageous owing to the rapid and accurate welding, which is accomplished with a minimum of heat treatment around the weld, giving slightly lower strength as compared to normalized base metal. The "fatigue resistance" of the new mount is stated to be higher than that of the gas-welded mount, in the ratio of 18-24 hrs. for the latter, against 120 hrs. for the flash welded mount, in a greatly accelerated fatigue test. WB (2a)

Cartridge Case Drawing, Annealing

"Small Arms Ammunition Manufacture." J. B. Nealey. *Iron Age*, Vol. 149, Jan. 8, 1942, pp. 29-34. Descriptive.

At the Lake City Ordnance Plant, the raw material for cartridge cases for 0.50 cal. ammunition consists of brass shapes already blanked, cupped and annealed. The alloy is usually 69% Cu and 31% Zn.

The cups are given 4 draws with an anneal after each of the first three. The draw presses are of the Bliss type. The material is lubricated prior to each draw.

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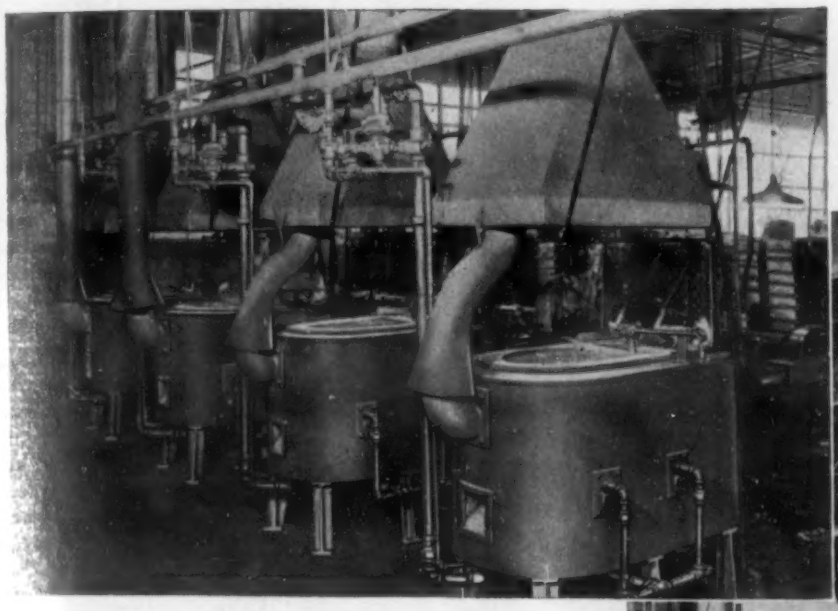

◀ **LEFT: A battery of MAHR lead melting pot furnaces in use in a large battery plant. MAHR pot furnaces for melting or for heat treating with salt, cyanide, etc. are fully described in Bulletin No. 110.**

RIGHT: Part of a battery of large MAHR car bottom furnaces used in an important defense plant for carburizing armor plate. ▶

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Annealing is done in a battery of natural-gas-fired continuous furnaces, with temperatures ranging from 1150° to 1400° F., and heating periods from 20 to 30 min. Each furnace is divided into heating and soaking zones to assure close temperature control.

The annealed cases are treated by an acid wash, 2 water rinses and a neutralizing soap rinse. The open end of the cartridges is cut off after the third and fourth draws, in rotating type trimmers.

The pocketing operation is done in a horizontal Ferracute press. The operation is accomplished by squeezing the case between the punch and bunter in a die. The extractor groove is turned in the head of the case on a Reynolds screw machine.

Another anneal is given to soften the case for tapering. The taper is necessary for reduction to bullet diam. and for each extraction after firing. The entire case is heated, but only the body and neck portions to the recrystallization point. This is done on a circular, horizontal plate with 56 depressions slightly larger than the case heads.

To avoid overstressing the neck when the bullet is inserted and to ensure satisfactory obturage, a second neck-anneal is given to soften it again, following the cold working in the tapering operation.

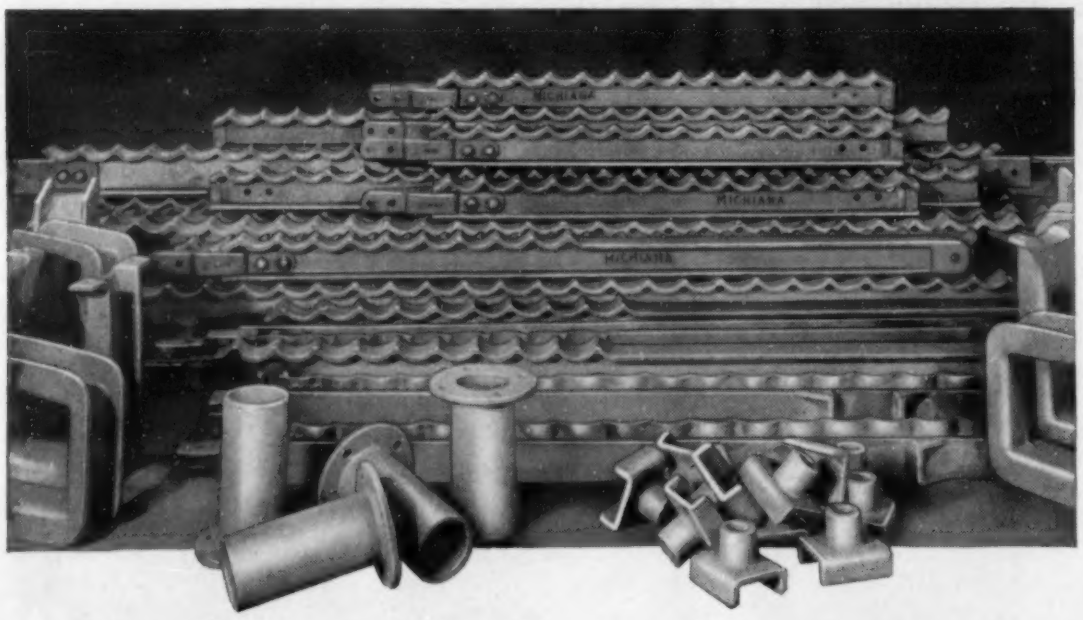
The raw material for 0.50 cal. bullet jackets (90% Cu and 10% Zn) is received in the form of cups. These cups are subjected to 4 separate drawing operations, but less frequent annealing is necessary.

Four presses are equipped with automatic hopper feeds, multiple punches and stationary dies. Dimensions are kept to close tolerances and the final jacket must be within 0.0005 in.

Two straight-line-action assembly presses are used to produce the finished bullet. In the first press, the jacket is given its correct profile and point, then it receives its soft lead point filler and hardened tungsten-steel armor piercing core.

Tracer bullet jackets are made essentially the same as armor-piercing bullets. The wall thickness is heavier; also more of the lead slug is forced into the point of the bullet, and the remainder is filled with tracer powder packed by a pressure of about 70,000 lbs./in.^{2} VSP (2b)

MICHIANA Heat-Resistant Alloy Parts for Walking Beam Furnace



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- Heat-Resistant and Stainless Steel Castings of all kinds.

Electric Furnaces for Heat Treating Non-Ferrous Alloys

"Electric Furnaces for Non-Ferrous Heat Treatment." J. E. Oram. *Metal Industry*, Vol. 60, Jan. 30, 1942, pp. 94-96; Feb. 6, 1942, pp. 108-111. Review of British practice.

The scope of heat treating equipment of all types is much greater in America than in England, and the gases available in America are more adaptable for protective-atmosphere use than those in Britain. Nevertheless, furnace-design progress in England has kept pace with that elsewhere.

The important factors in the choice of any particular furnace are the nature and size of the parts to be treated, the output required and the permissible cost. For this discussion, the following types of materials are considered: Light alloys (aluminum alloys and magnesium alloys), copper alloys (copper, brasses and bronzes), and nickel alloys (nickel, copper-nickel alloys and "nickel silver").

Light Metals

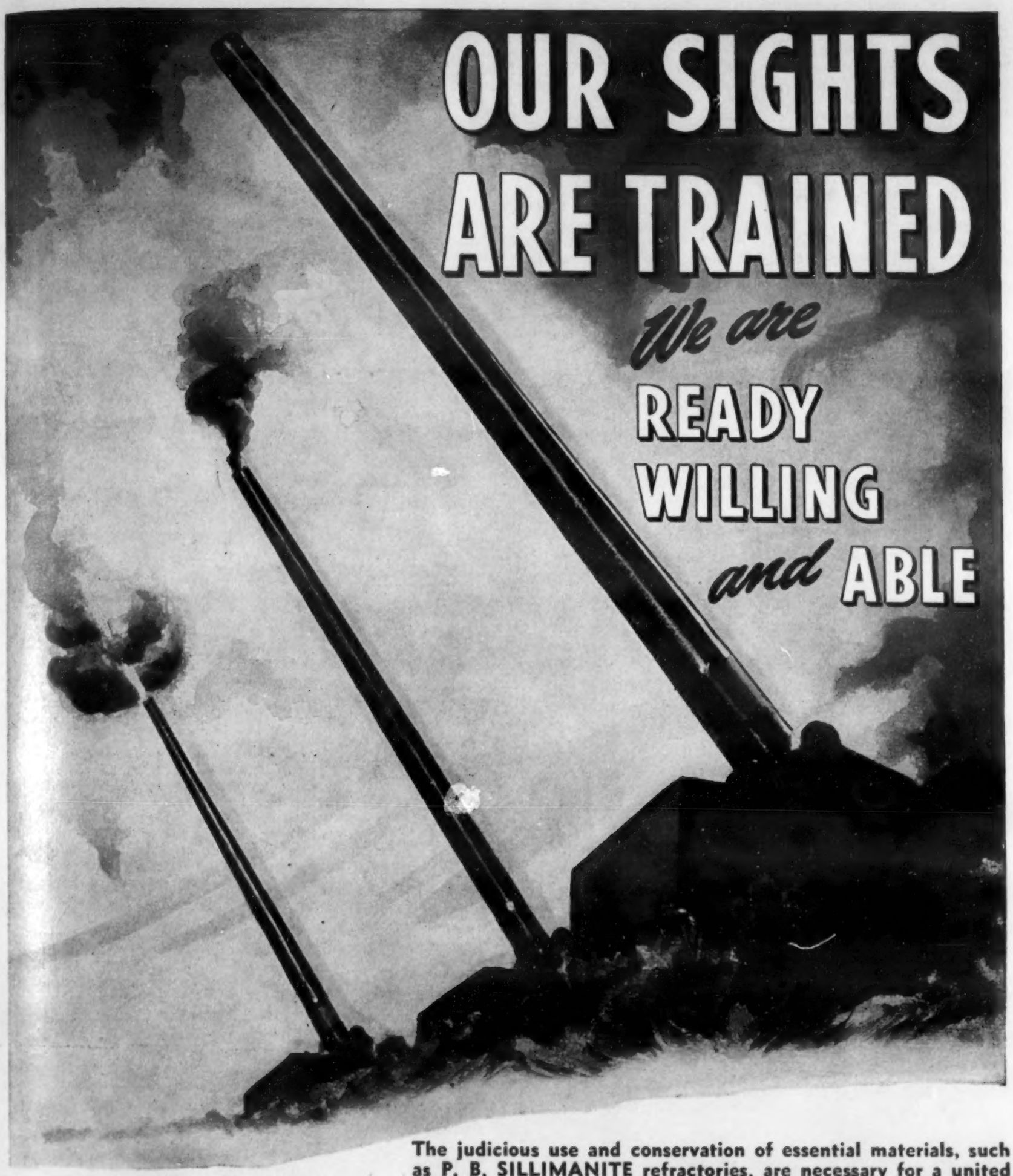
Requirements of light alloys as far as heat treatment is concerned fall into categories within the range 350°-1000° F., and this immediatetly indicates a narrow range of furnace types. Furthermore, with the exception of the use of sulphur dioxide sometimes employed in the annealing of magnesium alloys, controlled atmospheres are not required.

The main treatments for these materials embrace: (1) Billet heating for extrusion, stamping and forging, etc.; (2) annealing; (3) solution treatment; and (4) age hardening. Broadly speaking, two main categories of furnace may be considered—salt baths and forced air circulation furnaces.

The whole object of forced air circulation is to ensure a high degree of uniformity of temperature together with rapidity in heating the charge. At the temperatures involved in "dry" furnaces, heat transfer is mainly by convection, forced air being employed.

Two distinct types of forced circulation furnaces have appeared. In one, very popular in America, the source of heat is in a chamber separate from the treatment chamber; a fan circulates the air through the heat-supply chamber to the heat treating chamber and returns it to the first chamber for reheating. In the second type, the fan is placed in the heat treating chamber, together with the heating elements, using suitably placed baffles to control the path of air circulation.

In the case of continuous furnaces, the usual method is to provide fans at one end of the furnace, heating elements in the roof or in the roof and hearth, and air baffles in various forms—all designed to



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insure a high velocity circulation over the elements and through the charge.

Electric air furnaces are used in England almost exclusively for billet heating. Billets or blanks for small stampings weighing only a few ounces are usually heated in small batch-type furnaces. In the other end of the range are large continuous forging-billet heaters whose output may be 3-4 tons per hr. Furnaces with definite mechanical means for conveying large billets may have chain conveyors, slide rails, roller hearths, or walking-beam mechanisms.

Annealing (660°-750° F.), solution treatment (860°-970° F.) and age hardening (290°-360° F.) may all be satisfactorily performed in forced air furnaces, batch-type units being preferred.

Salt baths of the fuel-fired types have gradually been replaced by convected air furnaces, but electrically-heated salt baths are growing in use for annealing and solution treatments. The salts used must thus have melting points below this range. Alkali nitrate and nitrite mixtures are used, with the tendency now toward the use of nitrates only.

Copper and Nickel Alloys

For copper, brass and bronze, the important treatments are billet or slab heating and annealing. Nickel alloys are subject to billet heating and to process-annealing treatments. Billet or slab heating is generally done in furnaces similar to those for light alloys, except that forced air circulation is usually absent. The normal operating temperatures are around 1550° F., at which radiation plays a major part, as compared to convection, in heat transfer. Also, air circulation increases the scaling of copper and the dezincification of brass.

Annealing is preferably performed in controlled atmosphere furnaces, although often simple open furnaces with forced air circulation are used—or, to a lesser extent, salt baths. In treatments without the use of an atmosphere the choice of furnace will depend on the nature of the work—whether it is wire, sheet, strip, pressings, etc.

For large pressings, conveyor-type furnaces heating the whole or part of the pressing are now used. Ingenious conveying systems and heat recuperation are often employed to advantage. For example, the power consumption for straight annealing of brass at about 1200° F. is 120 kw.-hrs. per ton, and that of recuperative annealing in rotary drums about 70 kw.-hrs. per ton.

A further development that shows a still greater saving introduces certain novel features. Also of the recuperative type, it contains 2 specially designed trays moving in a reciprocating manner, which cause the work to travel forward through the chamber of one tray and return on the other.

The charge is fed into a hopper by means of a hoist, and leaves the hopper in a steady stream at a controllable rate. The ingoing charge is preheated by the outgoing charge, and as the heat losses through the design are remarkably low, the consumption figure shows still further improvement.

With both the furnaces just outlined, it is usual to provide a washing and pickling plant to clean the work after treatment. The use of protective atmospheres for brass annealing in these furnaces is not usual, for brass is difficult to produce perfectly bright annealed, and pickling provides the required finish at relatively low cost. However, both types can be provided with protective atmospheres for treating other work where this is desirable.

Controlled atmosphere furnaces may be divided into 2 main groups—batch and continuous. The former are usually bell-type furnaces with or without forced air circulation, or vertical furnaces with fixed or removable retorts.

Continuous furnaces may have mesh belts or other conveyors to carry the work. Optionally, the work itself—such as strip and wire—may be drawn through continuously, either horizontally or vertically.

A recent development is the application of the recuperative principle to bell-type furnaces. A number of bases are interconnected and also connected to a regenerative ammonia dissociation plant. The atmosphere is circulated from the already heated bell to a second cold bell, which is thus pre-heated, without destroying the controlled atmosphere. For the nickel alloys, it is not customary to use bell-type furnaces.

A simple and useful method of reducing the consumption of protective atmospheres in horizontal continuous furnaces involves a construction such that the entering and exit zones in the furnace proper form an arc of a circle. The effect of self-sealing ends is thus achieved, and in some cases a 60% saving in atmosphere consumption has resulted. (2b)

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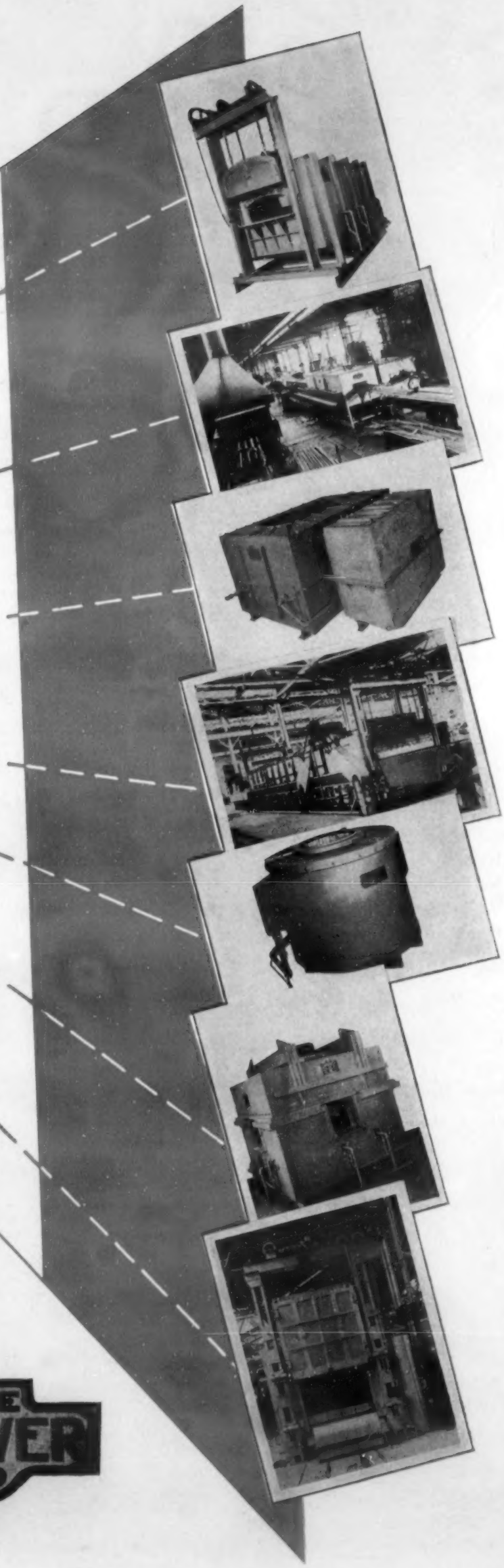

To the Drever Company, an industrial furnace is the engineered result of competent analysis of your heat treating problem. We do more than merely duplicate present equipment.

For example: whether it be a continuous roller hearth line for armor plate, a car type furnace for carburizing, a furnace for age hardening aluminum, or a furnace for bright annealing stainless steel—Drever engineers the job to be done, and the furnace to do that job is the result.

We're interested in giving you low cost per ton —high speed per piece—maximum production with minimum handling—or other specific combinations of qualities which your particular job requires.

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EXPERIENCE POINTS TO THE DREVER CO

Metallizing Aircraft Engine Parts

"Production Metallizing." H. E. Linsley (Wright Aeronautical Corp.) *Aero Digest*, Vol. 40, Jan. 1942, pp. 154, 159, 248. Descriptive.

Protection of the exterior surfaces of aluminum alloy aircraft engine components (especially cylinders) from atmospheric corrosion is commonly accomplished by painting. Even the best of paints, however, have a limited resistance to salt water spray, and since both a priming coat and a finishing coat must be applied, and each of these must be baked for a considerable time, the painting process, even when handled on automatic conveyors, is slow.

The introduction of the metallizing process, in which pure molten aluminum, itself highly resistant to corrosion, is sprayed on the parts, seemed to offer a solution to the problem. Initial attempts were made with the parts standing on a bench, and the spray applied with a hand gun. The first mechanical method consisted of mounting the cylinders on an arbor in an engine lathe and carrying the spray gun on the tool post.

The next method tried was to mount the parts on a power driven turntable equipped with a hydraulic jack. The spray gun was mounted adjustably on a post. The entire process required about 18 min. per cylinder, but this was not objectionable when production schedules were low.

With the recent advent of mass production, and the increasing demand for metallized cylinders, an improved method had to be found, and a completely automatic metallizing machine was therefore installed. The development of this automatic cleaning and metal spraying equipment is considered to be an extremely valuable contribution to the war production effort.

Manufactured by the U. S. Galvanizing & Plating Equipment Corp. in collaboration with the Metallizing Engineering Co., Inc., this equipment assures that the coating will be applied evenly to the full depth fins by holding the guns at exact angles, which are impossible to maintain with hand operation. The machine comprises 6 stations, each controlled by reduction gears and fully adjustable to various motions and speeds, and is capable of producing one finished part every 75 sec.

Each spray gun has an individual set of gages and controls mounted on a panel on the upper part of the machine within easy reach of the operator. Compressed air is supplied by a 60 h.p., 6-cylinder, water-cooled, Schramm air compressor with a 260 ft.^{3} delivery, and is dried by passing through a 300 ft.^{3} capacity water-cooled air drier.

Manufactured city gas is employed as the heating medium, and this is compressed by a 3 h.p., 2-cylinder compressor. Oxygen is piped over from a bank of cylinders located in the boiler house annex. An exhaust fan connected by a duct to the top of the machine removes the fumes of the burned gases.

In order to obtain proper adhesion of the sprayed metal, the surfaces must be thoroughly sand blasted. This is done on a specially designed Wheelabrator supplied by the American Foundry Equipment Co., Mishawaka, Ind. This large machine is entirely self-contained, and features 8 long arms projecting radially from a central hub.

The arms rotate within their housing, and as each arrives at the loading station a finished cylinder is removed and a new one slid into place. This sand blasting operation, previously performed in a small single-wheel machine, required 15 min. to complete. (2b)

Aircraft Metallurgical Engineering

The application of metallizing to a production engineering (as against maintenance) job in the aircraft field, described on this page, is a reminder of the increasing dependence placed by the aircraft industry on metallurgical engineering control. For other digests of specific interest to metal men in aircraft plants, see "Hollow Steel Propeller Blades" (page 665), "Flash Welding Aero Engine Mounts" (page 666), "Metals in Self-Compensating Springs (page 676) and "Heavy Duty Bearings" (page 684) in this issue.—The Editors.

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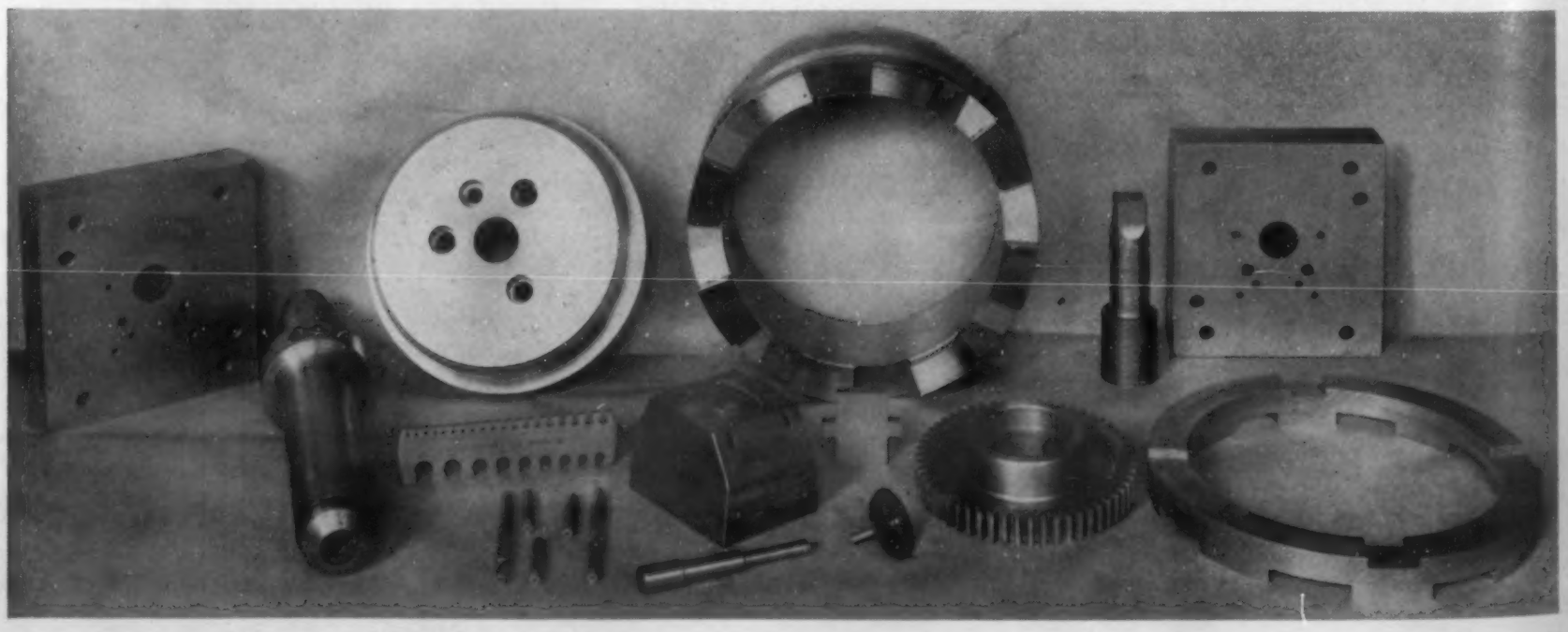

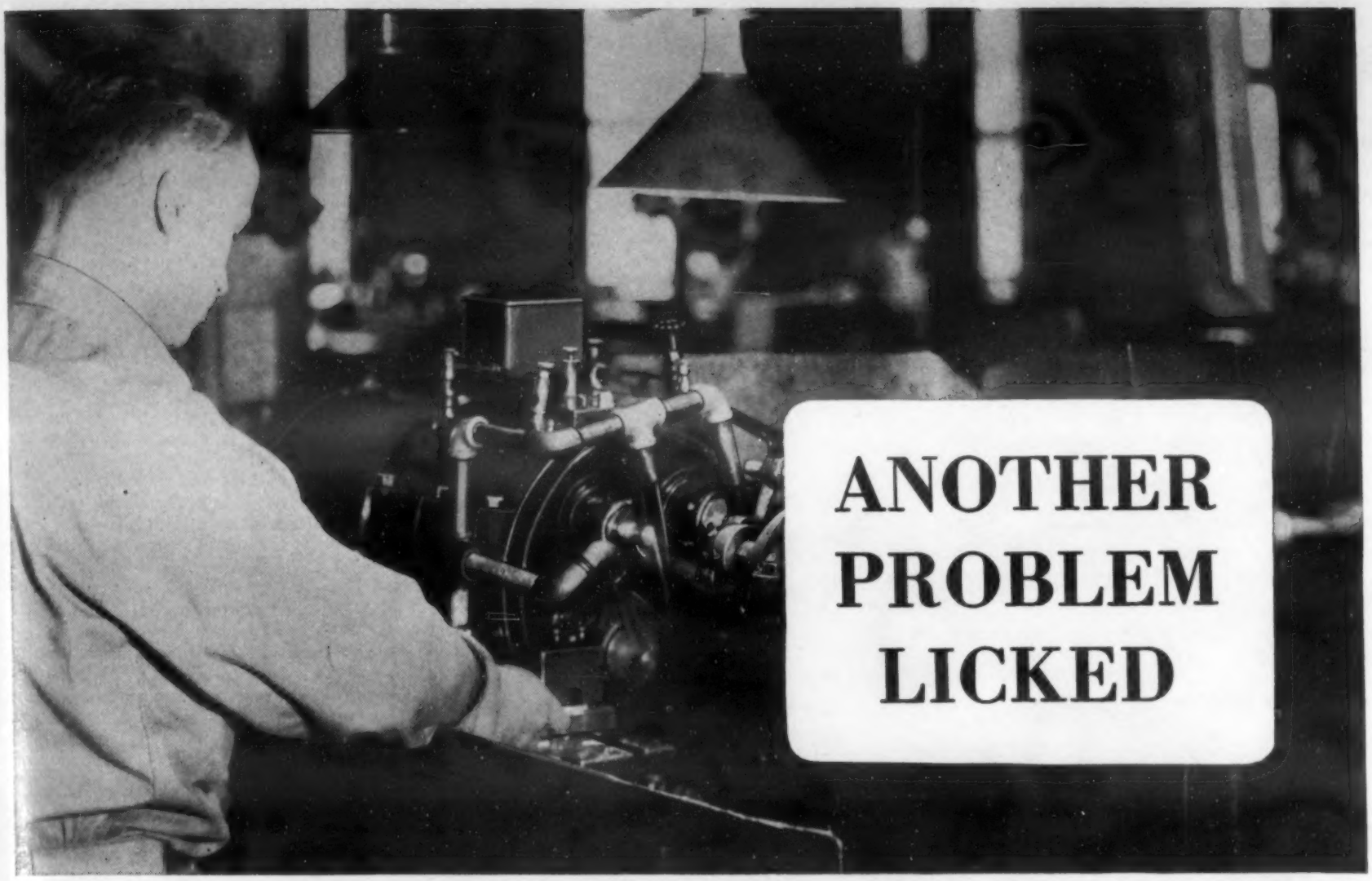

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METALS, ALLOYS, METAL FORMS
ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep) • Corrosion and Wear • Engineering Design of Metal-incorporating Products • Selection of Metals and of Metal-Forms • Competition of Metals with Non-Metals • Specific Applications of Metals and Alloys

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Metals in Self-Compensating Springs

"Aeronautical Applications of Instrument Springs." J. W. Rockefeller, Jr. (All-Weather Springs, Inc.) *Wire & Wire Products*, Vol. 17, Mar. 1942, pp. 139-141, 166. Descriptive.

With rapid developments in aircraft design, the range of temperature that airplanes may encounter has markedly increased until now the span is around 200° F.—from —50° to + 150° F. The effect of this wide temperature range on the stiffness of spring materials is considerable, as is shown in the accompanying table and, therefore, thermally compensating springs are necessary in the manufacture of accurate aircraft instruments.

In the design of instruments there is frequently an elastic element which operates in connection with the main spring, such as a bourbon tube or bellows. The rate of stiffness of this element is affected by temperature changes, usually in such a way that as the temperature decreases the element becomes stiffer, and it is necessary to have a spring whose thermal coefficient of elastic modulus will offset that of the element.

The bi-metallic self-compensating spring (U. S. Patent No. 2,236,158) has been developed to maintain a high degree of accuracy under wide temperature variations. The spring is usually made in 2 sections in the form of a helical extension spring or as a compression spring.

Per Cent Change in Stiffness for 200° F. Change in Temperature

Spring Material	*% Change in Stiffne*
High-carbon steel	2.8
Piano wire	3.0
5% Ni steel	3.2
Chrome-vanadium steel	3.0
18-8 stainless steel	5.0
Monel metal	3.2
Nickel silver	3.8
Beryllium copper	3.8
Phosphor bronze	4.2
Brass	4.4
Elinvar	.8

One section is coiled of an iron-nickel alloy, usually 36% Ni. The other section is beryllium-copper, steel or any desirable spring material, depending upon the properties sought in the combination. The ratio of deflection between the 2 sections under a given load is predetermined so that the temperature coefficient of elastic modulus of the combination will offset the algebraic total of all other temperature errors in the instrument.

Thus, with this type spring it is possible to produce any temperature modulus coefficient desired in the combination between + 6.4 and —5%. Besides, close control of thermal elastic properties is had regardless of any thermal elastic changes that may have resulted in the material from minute variations in chemical composition, cold working, heat treatment, etc.

Until recently the chief application of this spring was in spring scale construction. For such work, the extension type spring is used, one section of 36% Ni, the other of either steel or beryllium-copper.

In addition to extension springs, thermally self-compensating springs are made of the helical compression type, the sections being used in parallel. A 36% Ni iron alloy is usually selected for the section having a plus characteristic, and the other section is made of a variety of materials, depending upon the other properties sought. Where electrical conductivity

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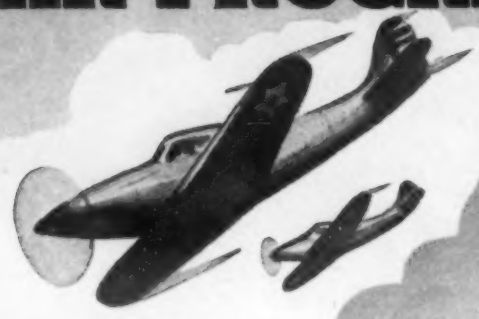

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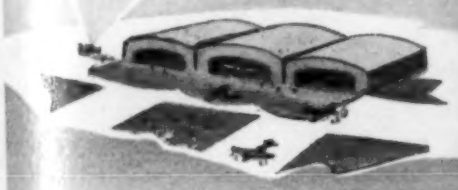

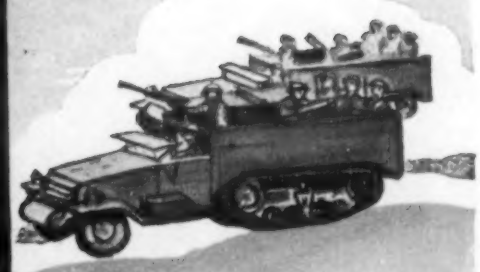

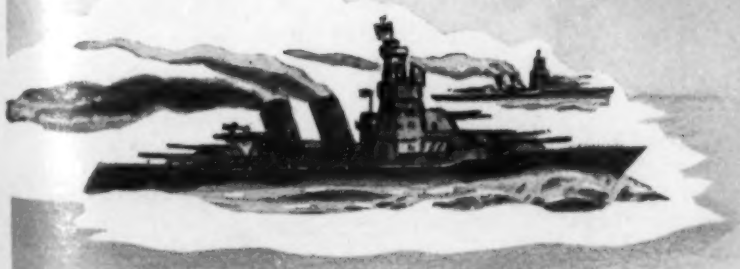

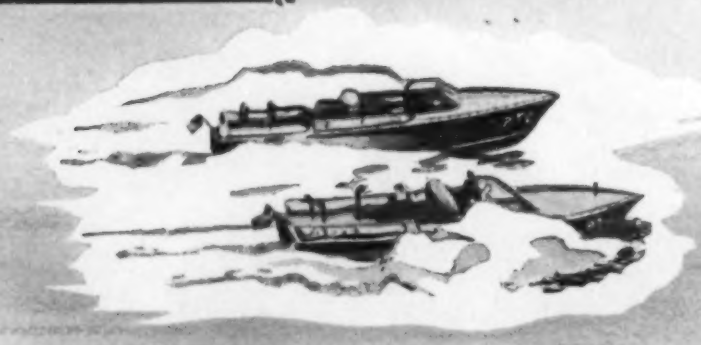

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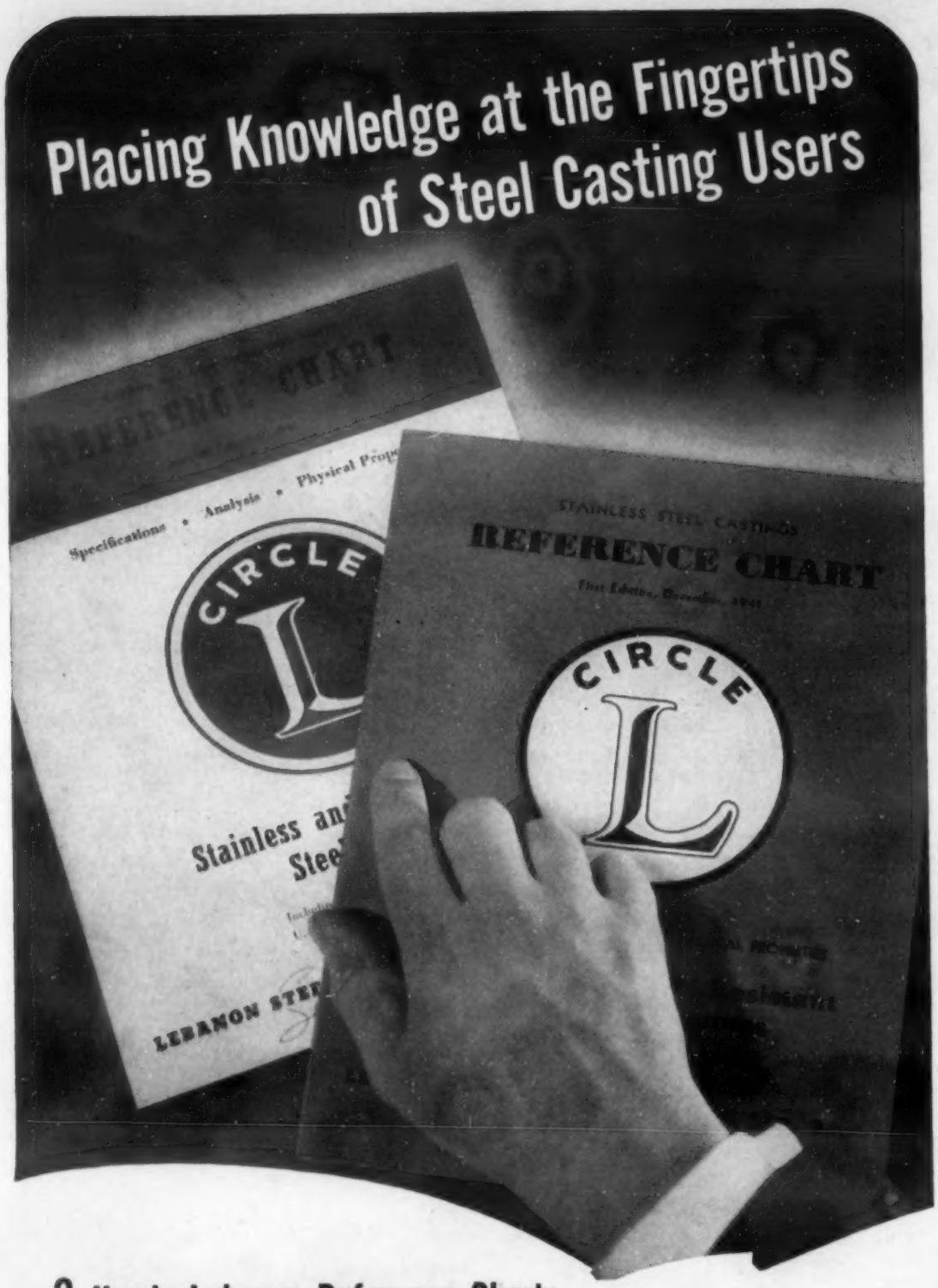

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CARBON AND LOW STRUCTURAL ALLOYS REFERENCE CHART (*left*)—Concise data on Lebanon Carbon and Low Structural Alloys. Specifications, analyses and physical properties are given. Also included are comparable classifications of U.S. Government, S.A.E. and A.S.T.M.

STAINLESS STEEL CASTINGS REFERENCE CHART (*right*)—Covers Circle Ⓛ Stainless, Corrosion Resistant and Heat Resistant Alloys . . . shows wrought and cast materials of comparable analyses. Designations, alloying elements, physical properties, heat treatment are covered.

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and good creep properties are needed, beryllium-copper is used; where space limitations are a ruling factor, a higher strength, steel music wire may be employed.

HRC (3)

Design Factors for Thermostat Metals

"THERMOSTAT METAL." S. R. HOOD (W. M. Chace Co.) *Bull. Am. Soc. Testing Materials*, No. 114, Jan. 1942, pp. 11-14. Descriptive.

The term "thermostat metal" is commonly applied to a composite material of two or more metals that, when subjected to a uniformly distributed change in temperature, changes its curvature due to the differing expansivities of its components.

The basic characteristic of thermostat metal is its tendency to change its curvature to temperature change. Materials can be made that (1) will have no deflection until some predetermined temperature is reached; (2) have an accelerated deflection rate; (3) a reduced deflection rate above some predetermined temperature; (4) no deflection above a predetermined temperature; or (5) reverse deflection rate above a given temperature.

There is no well-defined classification of thermostat metals, but the general divisions are "low-temperature" and "high-temperature" types. The low-temperature group includes invar (36% Ni iron alloy) in combination with brass or bronze. The high-temperature metals include all those that can be used at higher temperatures than are recommended for brass or bronze. A recently-added group has been the "circuit breaker materials," in which the element is heated by passing electric current through it.

A number of factors must be considered in selecting an alloy for a thermostat metal. The expansion coefficient must be investigated. The expansion rate on heating and cooling must be identical and any hysteresis would be very objectionable. The expansion rate should be reversible in any range for which it could be subjected and would include high temperatures if the thermostat metal were to be mounted by soldering, brazing or welding.

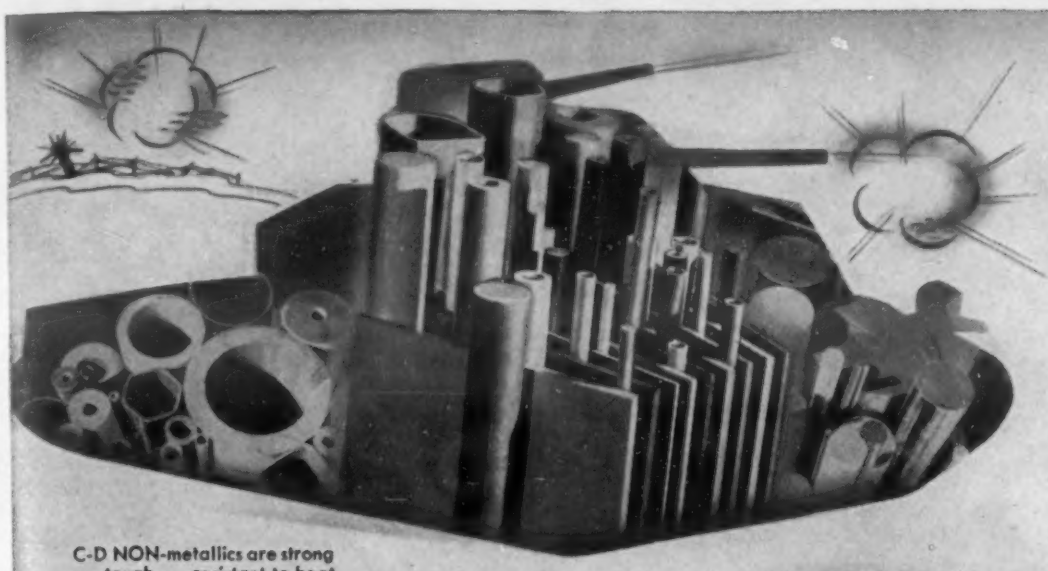
Strength characteristics of the alloy must also be considered. The strength at elevated temperatures is particularly important for high-temperature thermostat metal. In general, combinations having similar strength properties are preferable. The work that a thermostat element will do is important and involves the load to which the element will be subjected and its deflection. Unfortunately, deflection and load requirements usually do not permit the use of the most efficient thermostat metal element. Space limitations are more often the determining factors.

Good bonding of the component parts is essential. Since some portions of the bond are highly stressed at elevated temperatures, it is imperative that no low-melting-point or low-strength material be used as a bonding agent. A direct fusion weld is most desirable.

The hardness and elastic properties of thermostat metal are usually directly connected with the cold rolling of the metal, since most types of thermostat metal cannot be hardened by heat treatment. Superficial hardness is sometimes obtained by chromium plating.

Purchase specifications for thermostat metal strip usually include flexivity or deflection rate, resistivity, hardness, dimensional tolerances, flatness, straightness

To Help Industry Win



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limits, surface appearance, uniformity of bond, and some marking requirement to identify the low or high expansive component. HRC (3)

Corrosion Resistance of Electro-Galvanized Steel

A Composite

The position of zinc in the German industrial economy is reflected in the very large amount of space given to that metal in the Nazis' technical literature. The publication of special issues of German periodicals devoted entirely to zinc is not uncommon.

One such was the April 1941 issue of *Korrosion u. Metallschutz,* which contained numerous articles on zinc, galvanizing and the corrosion resistance of zinc and zinc coatings. Two of these, dealing with the corrosion resistance to electrolytically applied zinc coatings are of particular interest.

Although the utility of zinc as a protector of other metals has often been investigated, its own inherent corrosion behavior has generally been neglected. M. Schlötter & H. Schmellenmeier ("Ueber galvanische Verzinkung in sauren und alkalischen, matt und glänzend arbeitenden Bädern," *Korrosion u. Metallschutz,* Vol. 17, Apr. 1941, pp. 117-123) point out that the resistance of electrolytically deposited zinc against corrosion can vary quite considerably.

Their investigations show that electrolytic zinc deposits are not of uniform structure, so that it is incorrect to speak of "electrolytic zinc" as a definite material, but that there exist a great number of types of electrolytically produced zinc. All these different types can be characterized by their differences in the electrolytic potential; even sheets electrogalvanized with different current densities, show differences when compared one with another; *e.g.* a sheet galvanized with 80 amps/in.^{2} had a potential difference of 2 millivolt against one galvanized with 1200 amps./in.^{2} with the latter cathodic.

Electrogalvanized coatings is discussed by J. Korpiun ("Die Eignung der galvanischen Verzinkung zum Korrosionsschutz von Eisen," Ibid., pp. 123-127. Formerly electrolytic galvanizing was used only if the dull, gray color of the deposit was not objectionable. The development of better methods in the last 5 yrs. has permitted the production of bright and glossy zinc deposits with higher current densities and, therefore, in shorter time.

Galvanized coatings (especially electrolytic coatings) should never be employed, however, for purposes in which the zinc coating is exposed to conditions under which zinc itself is not resistant, *e.g.* in all agents of pH less than 7 or greater than 12, or in water of over 130°-140° F.—under which conditions zinc is not adequately corrosion resistant. However, zinc does provide some protection for iron in these circumstances, owing to the fact that in a local element of zinc and iron the former becomes the anode and under the influence of the atmosphere, dense, adherent and protective, carbonate layers are formed on the zinc.

The protection afforded by electrolytic zinc coatings in rural and industrial atmospheres is generally better than that of cadmium coatings. Against seawater, however, zinc is inferior to cadmium. Distilled water and condensate waters attack zinc but not cadmium. MH (3)

Metals for Seawater Exposure

"Engineering Research Committee on the Deterioration of Structures in Sea-Water." *J. Instn. Civil Engrs.*, Vol. 14, June 1940, pp. 383-391. Research report.

A summary is presented of the experiments carried out by a committee on the deterioration of structures of timber, metal and concrete, when exposed to the action of sea-water.

Results are given for 3 cleaned rolled irons; 5 carbon steels, 2 cleaned and 3 with scale; and 2 alloy steels with scale when tested at Auckland, Halifax, Plymouth and Colombo in sea air, at half tide level, and under complete immersion; 3 clean rolled irons and 2 cleaned carbon steels were also immersed in fresh water at Plymouth. Tables are given showing the combined losses in weight of bars of these alloys exposed for 5, 10, and 15 yrs. at each port and also their order of merit.

Best results in sea water were generally obtained with the rolled irons, followed by the alloy steels, while carbon steels with scale showed a better resistance than cleaned carbon steels. In fresh water cleaned carbon steels had a better resistance than cleaned rolled irons.

Tests on the protection of steel and iron by means of paints and other preservatives showed that in general, red lead paints, and mixtures of red and white lead, proved superior under aerial and half tide conditions, while under complete immersion conditions an iron oxide paint, and also a red chromate paint—the latter followed by a mixed red and white lead paint—gave good results. JWD (3a)

Steels for Mercury Vapor Equipment

"New Mercury-Vapor Power Plant." A. R. Smith & E. S. Thompson (Gen. Elec. Co.) *Steel*, Vol. 110, Jan. 12, 1942, pp. 52-53, 84, 87-88. Descriptive.

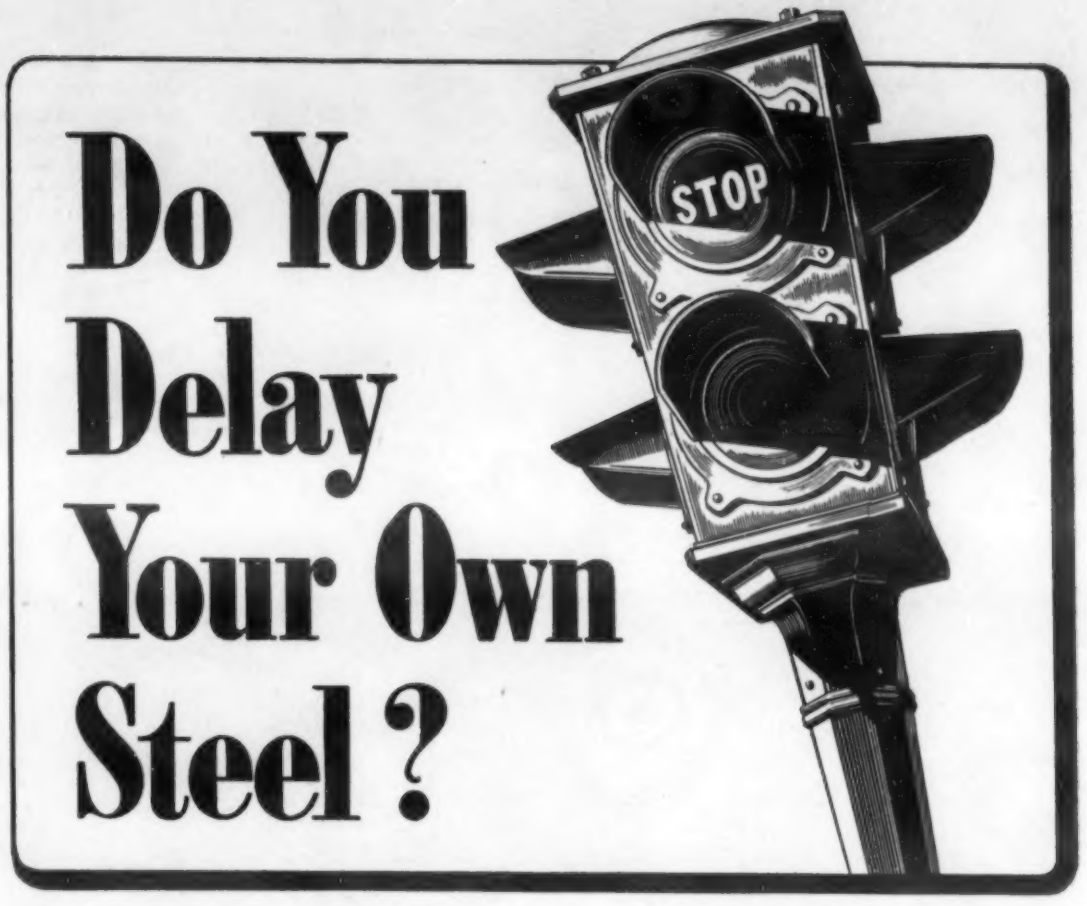
The early mercury boilers were made of low-carbon steel, generally Calorized by the dip method and then heat treated. Later, boilers used chromium-molybdenum steel tubes.

The results of long-time rupture tests of many steels at high temperatures and other considerations led to the selection, for the boiler tubes described, of a steel containing 0.10-0.13% C, 0.50 max. Mn, 4-6 Cr, 1.40-1.55 Si, and 0.45-0.65 Mo. While 3000 lbs./in.^{2} is the 100,000-hr. rupture strength of the low-carbon steel at 975° F., this alloy steel is equally good at 1140° F. In addition, it resists oxidation at operating temperature by the usual coal ash.

In cooler passes of the boiler, a steel is used (for the lower bundles of the fog bank) that contains 0.30-0.60% Mn, 2.75-3.25 Cr, 0.50 max. Si and 0.80-1.00 Mo.

The solubility of iron in mercury at high temperatures reduces the thickness of metal. Experience showed that the disintegrated iron and iron oxides were deposited in places on the heating surfaces in the lower temperature regions, frequently restricting or stopping the flow of mercury or vapor.

Tests with various alloys showed that the 4-6% Cr, 1 Mo steel in actual service was more resistant to mercury attack than carbon steel. However, another investigation proved that 1 part of titanium and 100 parts of magnesium per million, respectively, by weight, added to the boiler mercury completely stopped the loss of steel by solution. Also, reliable heat transfer between the tube and mercury was secured



Do you unwittingly hold up delivery of your own steel orders? Strangely enough, it's being done every day—even with a war going on!

In a typical instance, you might order steel to an Army specification—only to learn the "spec" covers 3 different variations of the same steel. Each variation has its own designation—the "spec" number alone is useless.

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as the mercury-titanium-magnesium alloy produces perfect wetting of the mercury-coated surfaces.

There are about 5000 welds in the boiler. The welding procedure was specified very completely and rigid inspection of welds was made. No leaks were found in the hydrostatic tests or during operation.

MS (3a)

Bacterial Corrosion Inside Pipes

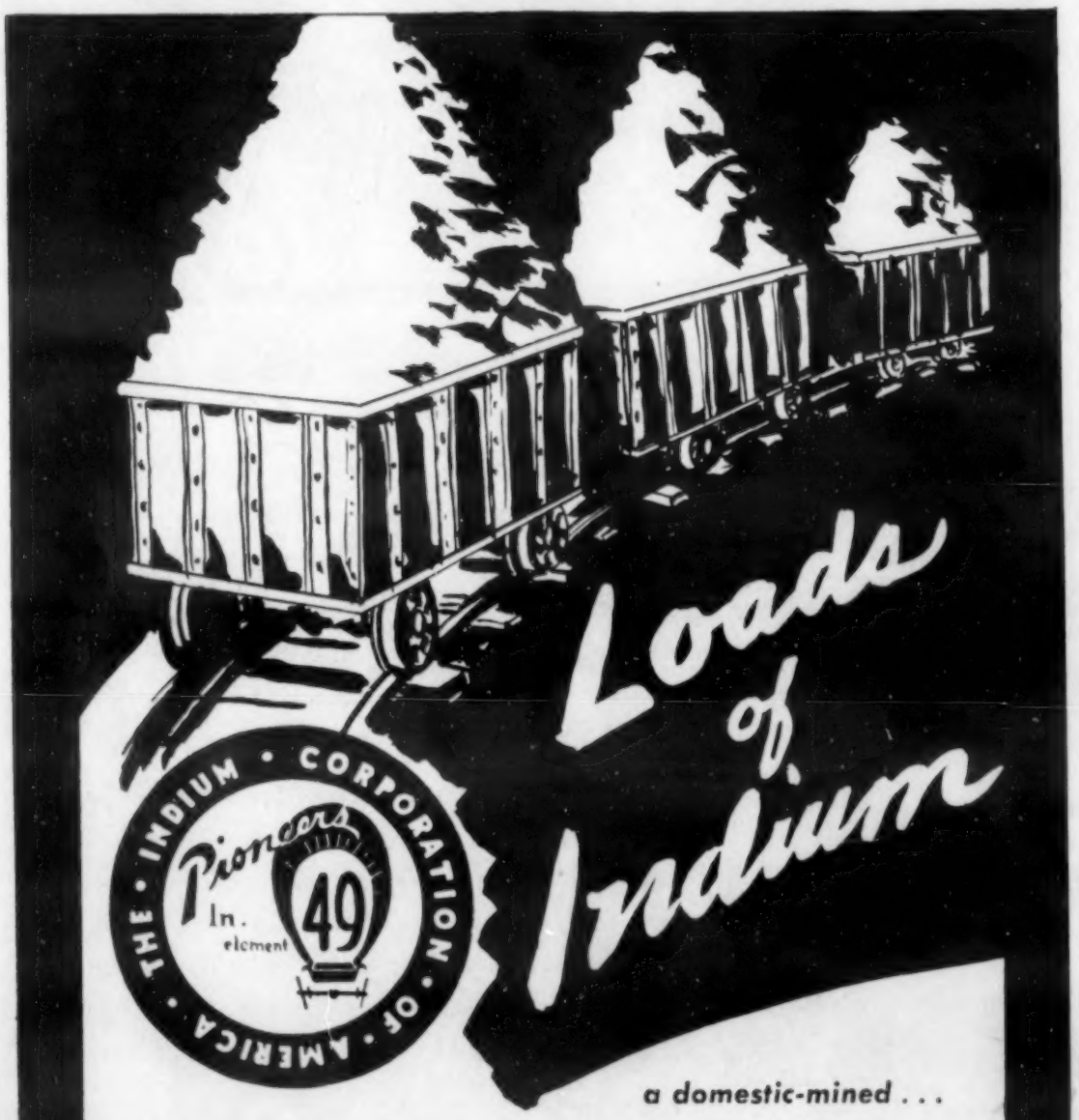
"Role of Bacteria in Corrosion of Iron and Steel." Arba H. Thomas (Am. Rolling Mill Co.) *Paper 2nd Water Conference, Engrs. Soc. Western Penn.*, 17 mimeographed pp. Review.

Several types of anaerobic bacteria have been associated with instances of corrosion of iron and steel pipelines. These bacteria fall into two general classifications—"sulphate-reducing" and "iron-consuming." There are instances where severe corrosion has occurred in pipe lines carrying water that was normally considered of only a mildly corrosive nature.

Severe corrosion of pipe lines carrying water containing these bacteria has been found to be more pronounced where the flow of the water in the pipe is comparatively slow, and where the organisms deposit upon the bottom of the pipe. When this occurs, conditions have been found to be very conducive to the rapid pitting and perforation of the pipe wall underneath these deposits.

Although a mineral analysis of the water may indicate it to be non-corrosive, the presence of these organisms may completely change the picture and cause severe corrosion. A bacteriological examination of the water will show the absence or presence of these organisms, and if present, the inside of the pipe may be given some type of coating as additional protection.

Also severe corrosion of pipe lines by these organisms can be eliminated by giving the water some type of treatment, such as chlorine. It is believed that the effect of these anaerobic bacteria on corrosion is indirect in nature rather than direct. (3a)



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Welded Gas Storage Tanks

"Welded Liquefied Natural Gas Storage Tanks." J. O. Jackson. *Welding J.*, Vol. 20, Dec. 1941, pp. 833-836. Descriptive.

Huge spherical tanks that contain essentially methane together with some butane and propane have been successfully designed for welding.

If stored at —116.5° F., the absolute tank pressure would be not less than 673 lbs./in.,^{2} therefore the temperature is reduced to —260° F., thus permitting storage at substantially atmospheric pressure. The rate of boiling or evaporation is controllable by means of tank insulation (granular or block cork 3-5 ft. thick).

Experimental work done to determine a suitable steel for the inner tank construction indicated that ordinary open hearth steel could be shattered with a hammer blow at —260° F., while 3½ Ni steel had high notch impact at this temperature (keyhole Charpy specimen). The tanks are, therefore, made of the 3½ Ni steel, welded with stainless steel (25% Cr. 20 Ni) welding rods. Charpy impact values of 20 ft.-lb. or more were consistently obtained in weld, fusion and heat-affected zones.

Special procedures had to be developed to weld the steel with these electrodes in the down hand, horizontal and overhead positions. These tanks represent a tribute to welding, for it is generally conceded that it would have been impossible to build them of riveted construction. WB (3a)

3b. Non-Ferrous

Heavy-Duty Bearings

"Bearings for Heavy-Duty Automotive Engines." Albert B. Willi (Federal-Mogul Corp.) *S.A.E. Journal*, Vol. 40, Feb. 1942, Trans. pp. 62-72. Practical review.

As tin-base babbitt possesses low compression, tension and hardness values, especially at higher temperatures, specialized bearing materials, such as the cadmium-base and copper-lead alloys were developed. These weaknesses of babbitt have been minimized and bearing capacities increased by chemical adhesion of the babbitt to the back, improved and controlled babbitt structure, and the use of thinner bearing linings.

At present, steel-backed babbitt-lined bearings with linings as thin as 0.0025 in. are being used in several engines and giving increased mileage. However, engines in which thin babbitt bearings are used must be well protected by efficient air cleaners and oil filters, since these bearings are particularly susceptible to abrasion by foreign particles in the lubricating oil.

Undersize bearings are often used for

ZINC IN WAR

16 FUZE PLUGS EVERY 12 SECONDS!

Any fabrication process which is capable of turning out 16 semi-finished metal parts every 12 seconds is geared to war production. That is why the die casting industry is now taking on the production of direct and indirect implements of war. That is why zinc alloy must be available in sufficient quantities to enable the die casting industry to make an all-out war effort.

Zinc alloy is the most widely used metal in die casting because, with the selection of the most appropriate alloy, it enables the production of castings having four outstanding characteristics: *Accuracy*—close tolerances can be achieved and maintained throughout the useful life of a casting; *Complexity*—intricate shapes are obtained to incorporate many features in a single part, thereby eliminating much machining and assembling; *Strength*—zinc alloy die castings have higher shock resistance than most other cast materials; *Economy*—all of the foregoing factors, plus long die life and low metal cost, add up to impressive production economies.

The die casting industry is doing a war production job (as typified by the shell fuze plugs shown in the background) and the zinc is there as needed. But this represents one more reason why it will be difficult for civilian users to obtain all of the zinc they would like to use.

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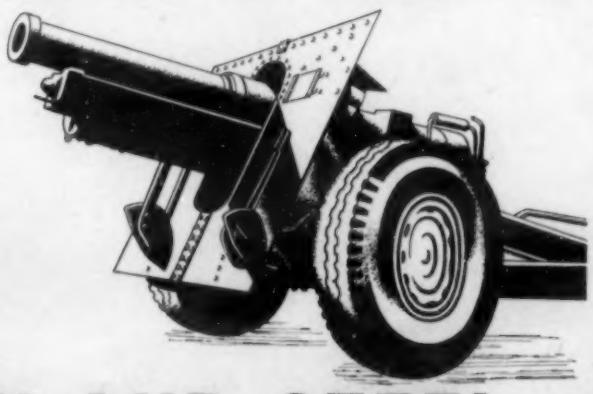

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replacements, but the use of thinner linings in such cases is difficult, because the steel-back thickness is held constant in the mills used for applying babbitt to a continuous steel strip. In routine replacement jobs, the bearings are affected unfavorably by worn and out-of-round crankpins and journals; bowed crank-shaft retained in line by force; warped crank-case; out-of-round connecting-rod bores and main bearing saddle bores; excessive dirt in engine; bearing caps misplaced sideways; improper oil clearance; fuel knock; and low oil pressure.

Despite these handicaps, the original or even greater mileage can be obtained by using bearings of increased load-carrying capacity, such as cadmium-silver-copper bearings. Addition of a centrally located internal annular oil groove will improve the load-carrying capacity of any bearing with a high length-to-diameter ratio.

The performance of copper-lead bearings has been excellent in some operations and very unsatisfactory in others. The use of these bearings will increase, because of the shortage of cadmium and tin. To obtain the best results from copper-lead bearings, their field of usefulness from an engineering and mechanical point of view must be known and recognized and they must be applied within the conditions of their field.

The unfavorable conditions enumerated above are harmful. Unfortunately, their manifestations are expressed in the appearance of the bearings themselves, and it is customary to question the metallurgy of the bearing rather than the mechanical conditions surrounding it. Examination of some copper-lead bearings that were claimed to have failed indicates there is no foundation for some of the criticism of these bearings.

It is natural for a copper-lead bearing surface to become coated with a varnish or lacquer deposit ranging in color from orange to brown, which is beneficial. Even when the deposit changes to a hard, bright, shiny, oily, black surface, it is difficult to connect it with real trouble. A soft, dull, black deposit similar to dried-out sludge, often due to the use of high-detergent oils in an old engine, has not been shown to be harmful, either. A hard, dull, black deposit of lead and copper sulphide indicates corrosion of the lead by certain petroleum acids formed in the oil as a result of excessively high operating temperature. MS (3b)

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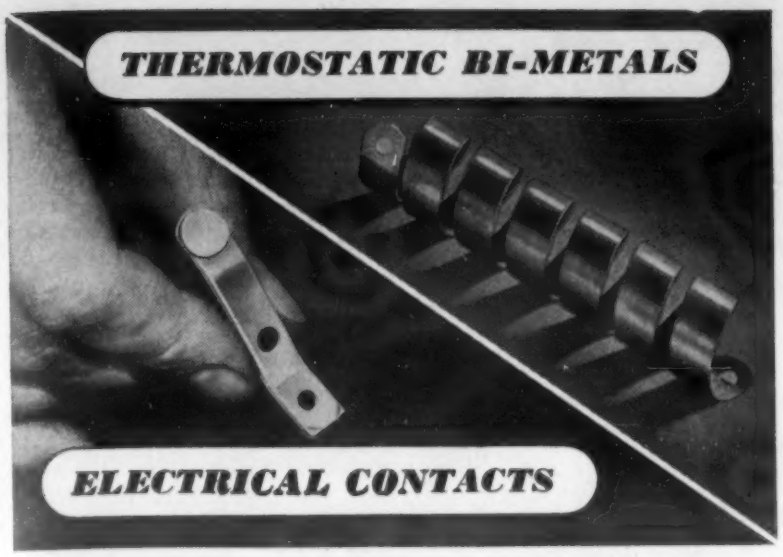

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Fatigue Testing

"Facts and Fallacies of Stress Determination." J. O. Almen (General Motors Corp.) *S.A.E. Journal*, Vol. 50, Feb. 1942, Trans. pp. 52-61. Review.

No means are yet available for reliable determination of stresses in dynamically loaded, highly stressed machine parts. Stress calculations are entirely inadequate except for a few special cases. Photoelastic analyses, extensometer readings, brittle lacquers, etc. do show major stress patterns but fail to provide reliable quantitative stress values.

It is in the design of machines where weight is all important, as in airplane engines, or where weight and cost must both be considered, as in automobiles, that the inadequacy of our means of stress determination and our ignorance of fatigue strength of materials are most keenly felt. Published fatigue test data are not directly applicable to design of light-weight, high-output machine parts for a number of reasons.

Most investigators test their specimens at stresses so low that the specimen will last for an infinite number of stress cycles without failure. On the other hand, many machine parts are operated at maximum stresses above the fatigue endurance limit, and when failure occurs, it actually is due to a relatively small number of stress cycles at maximum stress.

From various published data, it can be hypothesized that, except possibly for very ductile metals, the slope of the fatigue curve may be considered a measure of true stress and that the fatigue curves for varying stress concentrations converge toward a point near the tensile strength of the material and at some considerable number of stress cycles. If this is true, the present method of testing parts to failure and comparing the number of stress cycles at constant load that each part will withstand is subject to serious error.

True comparisons can be obtained only through fatigue tests on a sufficient number of parts at varying loads to outline the slopes of the scatter band limits. Accumulation of results of present routine tests on a fatigue diagram will make available in a relatively short time, fatigue curves and their scatter bands for a large variety of parts.

In the very few cases where over 100 tests have been run at sufficiently large load range on commercially identical parts, the scatter of the test points falls within a well-defined pattern which tends to radiate from a point at high stress and low number of stress cycles and to diverge to a broad band at low stress and high number of stress cycles. Fatigue curves constructed from information given in catalogs of bearing manufacturers confirm the hypothesis that the slope is a measure of stress.

The somewhat common belief that reliable tests can be conducted in the laboratory by reproducing conditions of service is erroneous. Many laboratory tests for grading materials and processes have been costly to industry.

For example, impact tests led to the belief that a carburized part should have a hard case to resist wear and a tough core to resist breakage. Heat treatments were specified to bring out the best compromise between these alleged requirements of case and core. These heat treatments were not the best for either region and resulted in lowering the quality of many millions of gears before it was realized that gear-teeth fail by fatigue and that fatigue failure, for the usual depth of carburization, always originates at the surface of the case.

Alloy steels have been used in gears and

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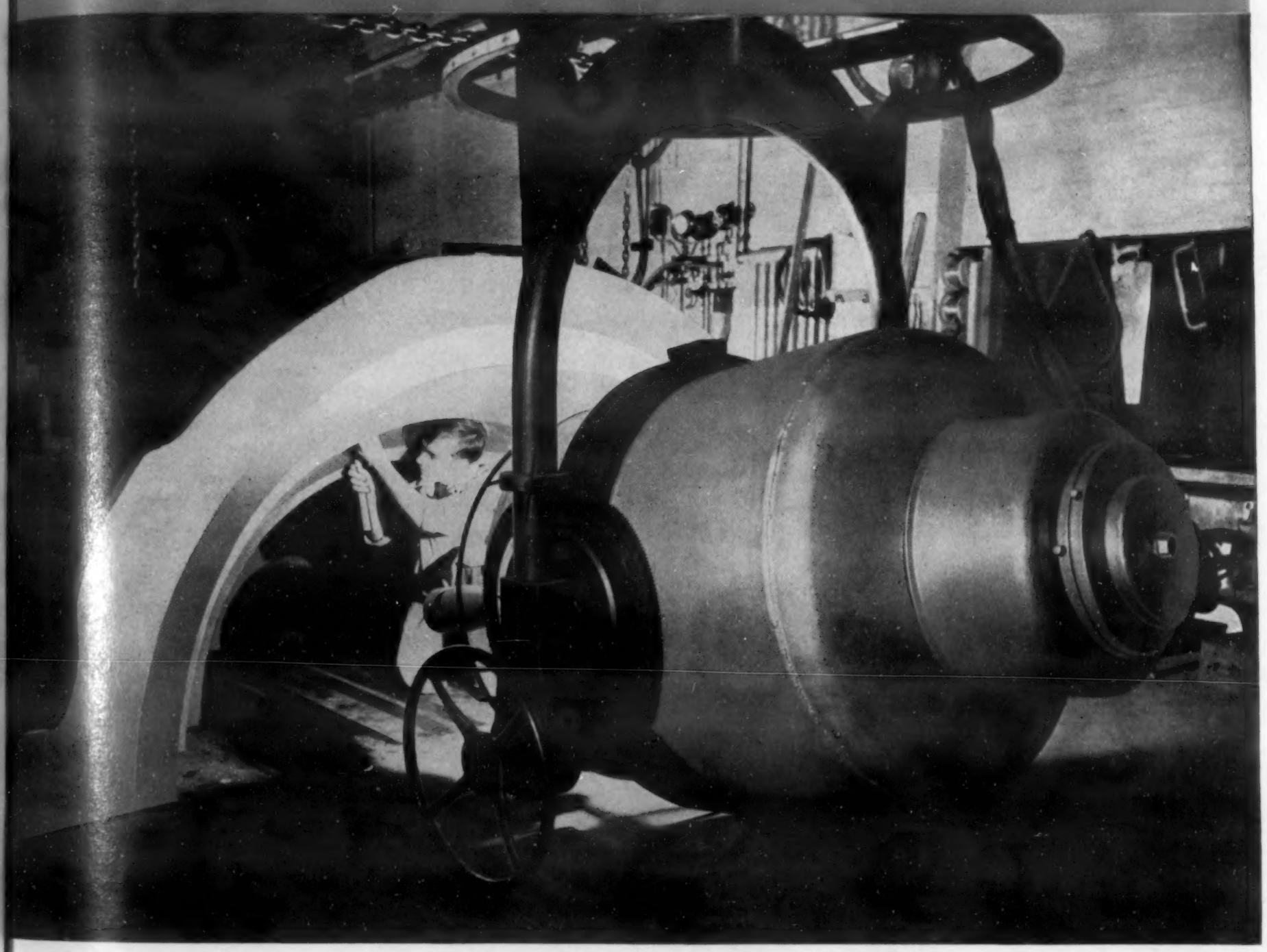

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other parts because of the results of laboratory tests, including fatigue tests of ideal specimens. Fatigue tests of actual machine parts correlated with service records have shown that there is no detectable difference between the high-priced alloy steels and the low-priced alloy steels when used in many machine elements.

Diagrams of effect of stress range on fatigue life indicate that the slope of the fatigue curve varies with stress range as well as with stress concentrations. If the hypothesis regarding slope and stress is changed to state that the slope of the fatigue curve is a function of effective stress, the hypothesis will apply for any stress range.

Fatigue tests must duplicate service failure as to location of fracture and, in many cases, must produce failure in about the same number of stress cycles, if accurate life comparisons are to be made. This requires that normal-operation stress be distinguished from the relatively infrequent overloads that caused the failure.

If a large number of fatigue test points are available for a machine part, empirical formulas can be developed for accurately calculating load capacity of that part, by the method followed in arriving at the load capacities of automobile gears and ball- and roller-bearings. MS (4)

The Nick-Break Test

"Woody Fractures." R. K. Kulp (Timken Roller Bearing Co.) *Iron & Steel Engr.*, Vol. 19, Feb. 1942, pp. 39-63. Experimental.

Experimental work with the nick-break test has shown that the thickness of the sample and the method of breaking are the most important factors in determining the nature of a fracture. Samples below ½ in. in thickness were usually woody. From ½ in. to 1½ in. the samples were critical in that they were most sensitive to methods of breaking and the presence of non-metallics. Above 1½ in. in thickness, the samples were usually granular.

Structural grain size and non-metallics have been found to be causes of woody fracture. The factor of cleanliness is important in determining the nature of the fracture but the results in the nick-break test above cannot be considered as a satisfactory index of steel quality.

The contrast in appearance of granular and of woody fractures may be explained by mechanics of rupture. Granular fractures result when the cohesive strength of the crystallographic phase is exceeded before deformation sets in and fracture occurs along cleavage planes. Woody fracture occurs only after pronounced deformation takes place and rupture occurs along slip planes.

The evaluation of plate quality by use of the nick-break test requires careful consideration of all factors involved. It is recommended that this method of testing be supplemented by other tests such as macro-etching or metallographic examination, particularly if the application is one where cleanliness may be a factor. CBJ (4)

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Tests for Weld Cracking

"Weldability—Cracks and Brittleness Under External Load. Part III. Tests for Cracking Under External Load—Impact and Tensile Tests. A Review of the Literature to July 1, 1939." W. Spraragen & G. E. Claussen. *Welding J.*, Vol. 20, Nov. 1941, pp. 522s-552s. Correlated abstract of 199 references. For previous sections, see Metals and Alloys for Dec. 1941, p. 912, and Feb. 1941, p. 340.

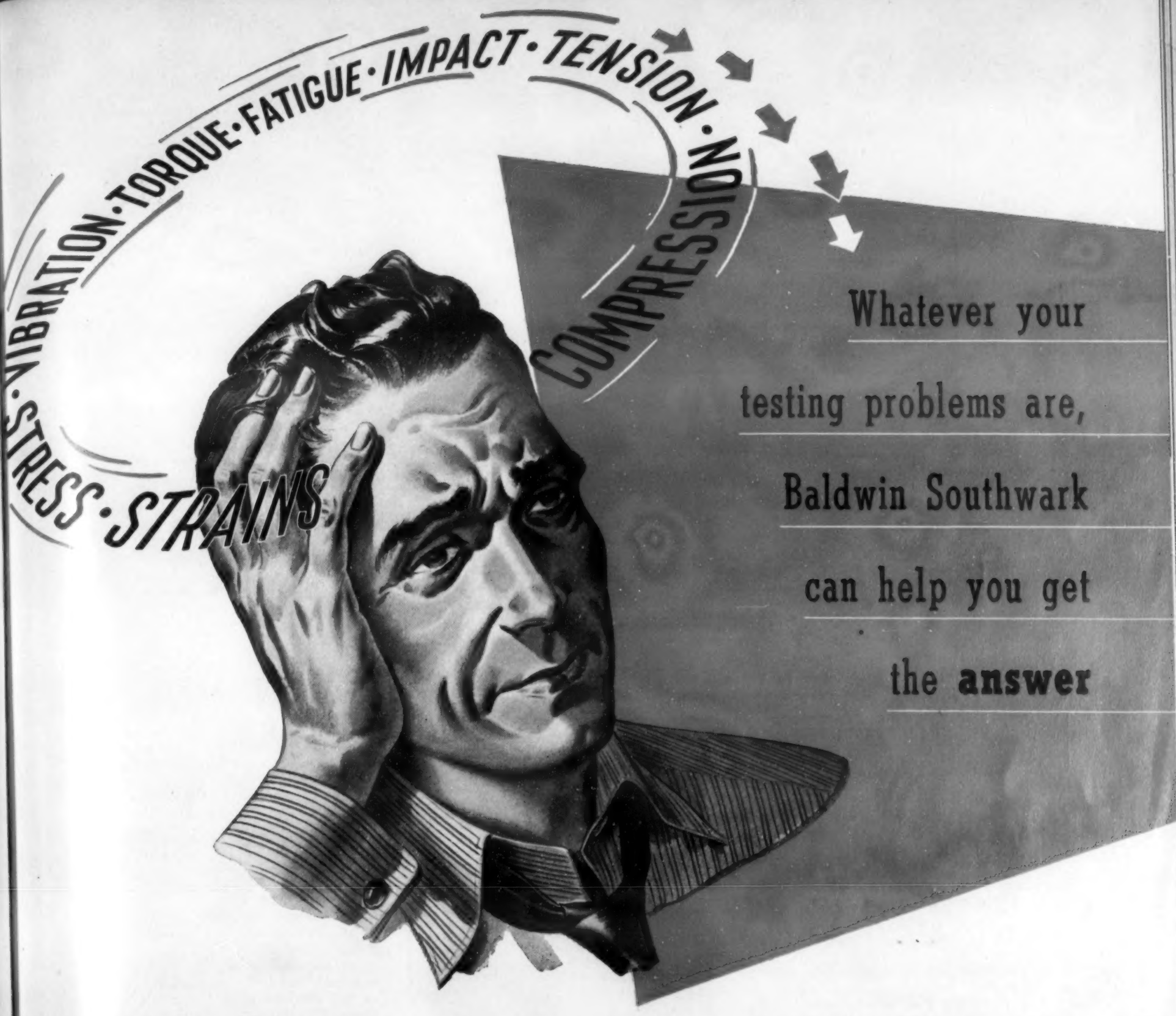
The tests covered by this review are (1) impact tests, of which there are at least 6, (2) tensile tests, discussed under 10 different headings, (3) shear and torsion tests, (4) compression tests, (5) fatigue tests, (6) hot forgeability test, (7) cold rolling test, (8) rigid frame test, and (9) miscellaneous tests.

In the tensile-impact test fracture always occurs in the soft weld metal with practically the same properties indicated as in the static tensile test. Notch impact tests of weld metal are sensitive to welding procedure since a larger amount of unrefined weld decreases the impact value; annealing increases the impact, and a low impact of 5.5 ft.-lbs. Charpy is associated with rapid propagation of cracks.

Notch impact tests of the heat-affected base metal indicate that in the absence of a Widmanstaetten or martensitic structure and no cracking due to thermal stresses, this zone usually had higher impact values than the base plate. Tensile tests made on all weld metal specimens give fictitiously high elongation in the presence of porosity and slag inclusions because of the abnormal local stretching around these areas.

The appearance of fish eyes in the fractured tensile test specimen is considered to be due to a locally embrittled or cracked area of hydrogen concentration. If the weld is subjected to a stress relief heat treatment which may also redistribute the hydrogen or partially remove it, the fish eyes do not appear.

The notch tensile test is considered by some to give more pertinent service properties than the static tensile test. Brittle behavior is exhibited by materials having high



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resistance to deformation (strained and aged steels, weld metal with high nitrogen content) and low breaking strength (overheated steel, cast structures) especially as the stress conditions (shrinkage stresses and notches, poor root fusion, etc.) become more severe. The yield strength of the notched specimen is considered by some to be more important than the tensile strength.

In fatigue tests of welds the two most important factors are the minimum tensile strength of any zone in the joint and particularly stress concentrations caused by unmachined welds and inadequate root fusion. In general, the higher the tensile strength, the greater is the effect of a notch in lowering fatigue strength. As a result, fatigue cracks start in unmachined welds in high tensile steel at little higher stress than in mild steel.

One of the conclusions drawn from the fatigue review was that hard zones (zones of maximum tensile strength in the heat-affected base metal) have no effect on fatigue value. WB (4)

Precautions in Handling Radium

"PROTECTION OF PERSONNEL HANDLING RADIUM." L. F. CURTISS. *Bull. Am. Soc. Testing Materials*, No. 114, Jan. 1942, pp. 21-24. Descriptive.

The increased use of radium for radiographing heavy castings and other metal parts has brought with it problems in the protection of personnel. The individual preparations of the radium element used range from 50 to 500 mg. and all the general precautions necessary in handling radium must be strictly observed to avoid injuries.

Injuries may be produced in one of two ways. There may be local injuries, due to over-exposure of a part of the body, sometimes described as a "radium burn." The second type of injury is that produced by a general exposure of the whole body to gamma radiation from radium preparations that may be some distance away.

In devising safe methods of handling radium, the most important consideration is to take advantage of the fact that the radiation intensity decreases as the square of the distance from the source of radiation. The storage vault should always be placed as far as possible from locations regularly occupied by personnel.

In the actual manipulation of the radium, long-handled forceps, remote controls and other arrangements should be utilized that permit the operator to be as far as possible from the radium.

Another important factor is the time of exposure. Operations and manipulations with radium should be conveniently arranged so that all handling can be carried out quickly to reduce the possibility of general dosage of the whole body.

It is very important to note that once safe conditions have been established, it cannot be assumed they will remain safe. Shifting radium from one place to another or additional radium brought in creates new conditions. The author developed a type of Geiger-Müller counter, which is sensitive to gamma radiation and which can be used to explore a given set of conditions as well as to detect changes in exposure conditions.

The sensitive element of this exposure meter is a small Geiger-Müller tube counter sealed in a Pyrex glass tube filled with a mixture of argon and alcohol vapor. The counter tube functions by releasing an electrical discharge between the central wire

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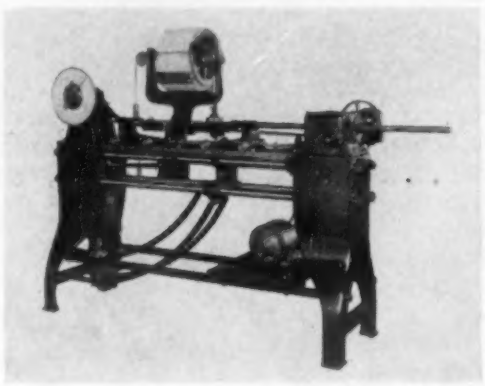

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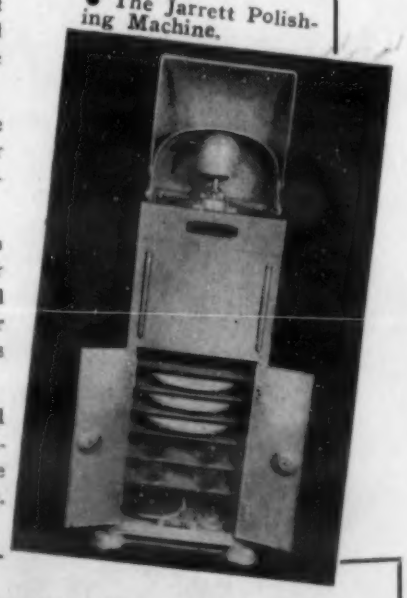

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When the instrument is used as an exposure meter, it may be calibrated in roentgens per day. [*The tolerance dose generally regarded as safe is 0.1 roentgen per 8-hr. day. Although this is being generally accepted, there is still some controversy as to the safe permissible dosage.*—H.R.C.]

Besides providing a continuous check of the exposure on rapidly changing conditions, this instrument may also be used to survey the intensities of gamma radiation in the neighborhood of a radiographic assembly and thus determine the safe working regions.

The calibration of the instrument should be checked occasionally by the use of a small standardized preparation of radium. HRC (4)

Macro-Inspection

"Macrographic Examination of Metals." Neil Metcalf. *Can. Metals & Met. Inds.*, Vol. 5, Jan. 1942, pp. 2-5, 9. Review.

Satisfactory examination of metal surfaces and even interiors for production control or "trouble-shooting" purposes can often be achieved by macrographic inspection. Its tools are the knife, file, magnet, magnifying glass, grinding wheel and etching reagent.

Macroscopic examination deals with the study of surface characteristics, or of the relatively gross features of interior structure that are revealed through observation of fractures or through etching, but without resort to magnifications higher than 10X.

An old-time method of determining the effect of various hardening temperatures on a batch of steel was the Metcalf test, in which a bar is nicked at intervals along its length, placed in the heat in such a way as to produce a temperature gradient along the length, and then fractured at the nicks so as to correlate the "desired" fracture with the "known" temperature.

The guesswork has been partially removed from this test by nicking the bar longitudinally and measuring the temperatures along the length by fixed thermocouples. One of the best known such modifications is Shepherd's penetration-fracture test, which employs an arbitrary set of 10 fracture standards produced by quenching from various temperatures. It should be noted that Shepherd's test specimens are hardened throughout, although samples to be tested do not always harden to the center.

Under conditions of repeated stress, a type of bright crystalline fracture quite different from the normal fibrous break may occur, and its appearance has led to a popular misconception of the cause of failure and to misuse of the word "crystallize" [*see innumerable "Chuckles" and Editorials signed "H.W.G." in this magazine*—F.P.P.]. Actually, the cold work induces a hard skin on the metal, a fine crack forms on the surface, the stress concentration causes the fracture to go right across the piece, following the grain boundaries and showing a bright crystalline appearance.

Macro-etching is a simple method of quick checking surface structures and of roughly comparing the metallurgical quality of different lots of material. Macro specimens are often etched on sawed samples, without grinding or polishing, the etching being more drastic than for *micro* specimens.

When surface defects like seams, laps, etc., are sought, preparation is often unnecessary. Surface scale will be removed by the etching reagent. However, internal inspection requires preparation; weak etching solutions require polished surfaces.

Samples should be in a soft condition if possible. If only a hardened specimen is available, it should be stress-relieved to avoid the development of cracks from the etching itself. Care should also be exercised with grinding in such cases, or checks may develop.

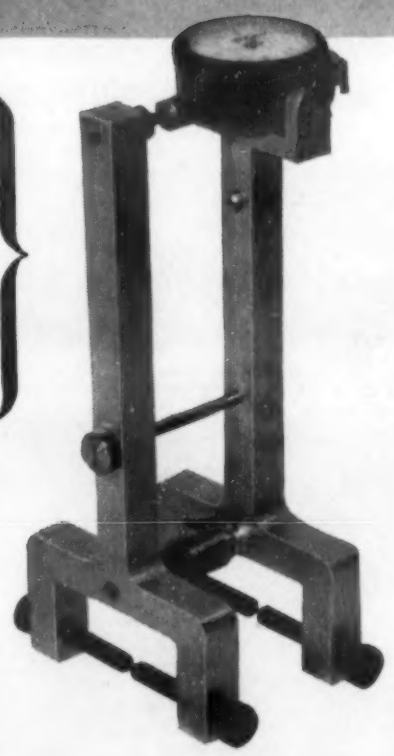
Although many etchants are available for studying various structures, in 9 out of 10 cases a 50% hydrochloric acid solution at 160°-175° F. employed on a saw-cut, machined or rough-ground surface will give good results. Etching time varies from 15 min. to 1 hr., the more complex steels requiring the longest time.

Surface seams, internal cracks and pipe are easily recognized, but evidence of segregation is likely to be misinterpreted. Not every pit indicates segregation, for pits may occur through the attack of the etchant around carbide particles.

Often misinterpreted also after deep etching is the so-called "pattern effect," which is the ingot pattern persisting through the hot work. In the absence of inclusions, it is often entirely harmless. FPP (4)

Averaging EXTENSOMETER

QUICK
ACCURATE
LOW ZERO ERROR



The H. F. Moore extensometer is ideal for determining yield strength, elastic limit and proof stress, as stipulated in Federal Specification QQ-M-151 a.

In addition to low zero error its large dial gage easily permits the reading of strains down to 0.00002 inch per inch of gage length. The gage is easily attached by screws which hold it firmly in position.

Adaptable to a wide variety of test pieces from 0.505 to 2 inches in thickness the H. F. Moore extensometer accurately averages strains on both sides of the specimen. Extension rods quickly convert it from 2-inch to 8-inch gage length. Write for Bulletin 153-A describing Southwark's line of strain gages and extensometers.

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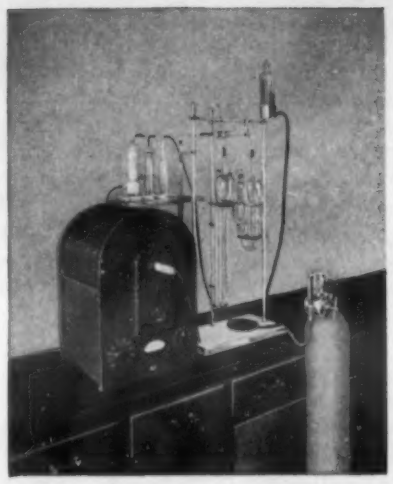

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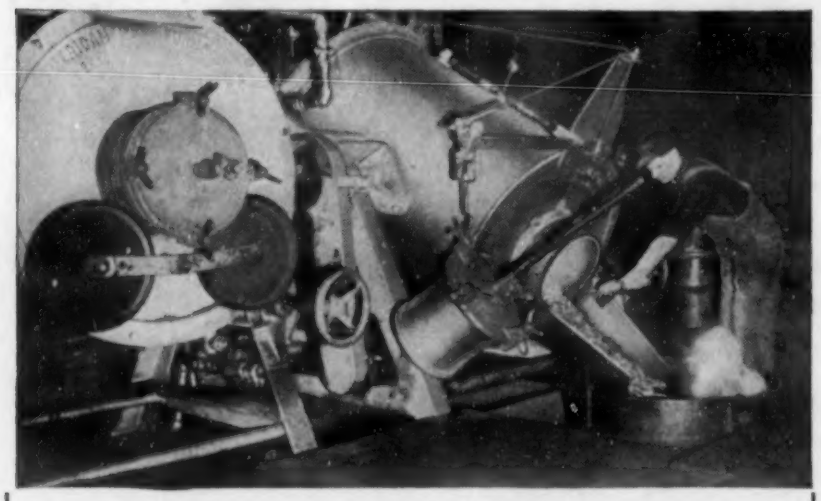

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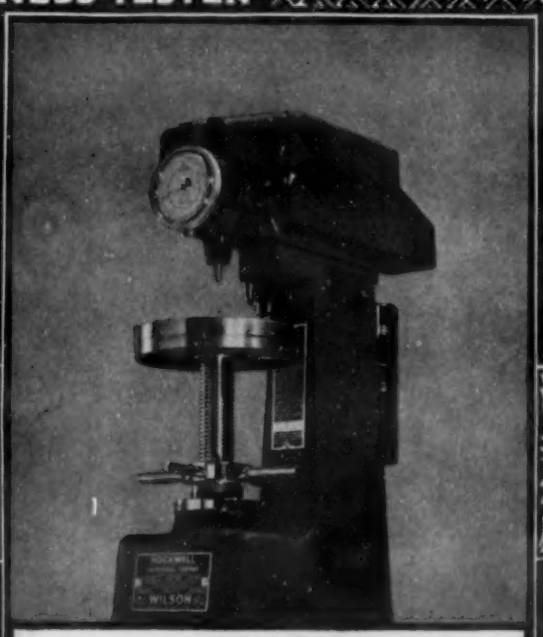

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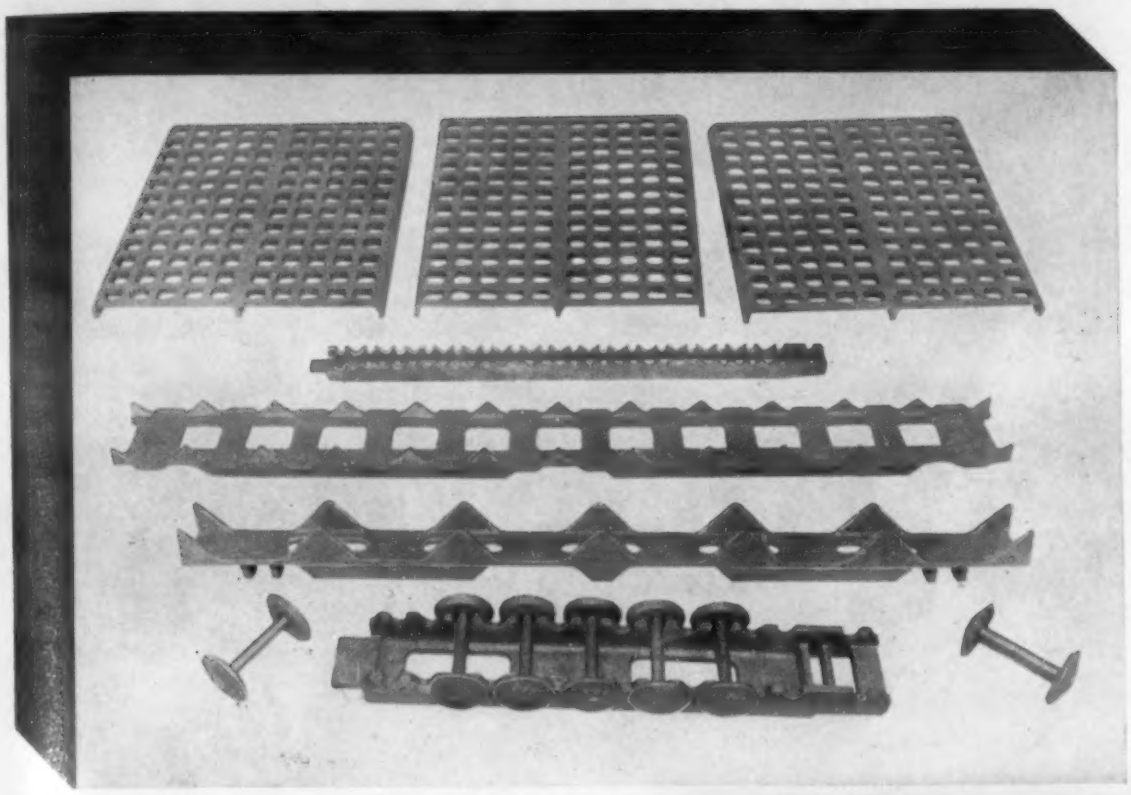

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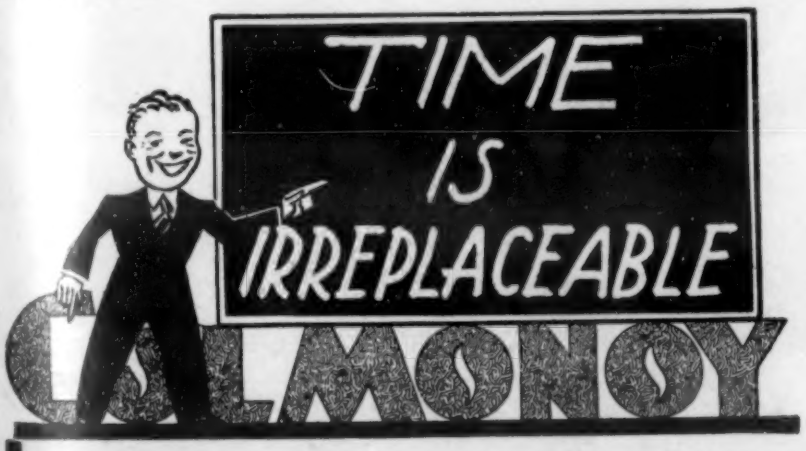

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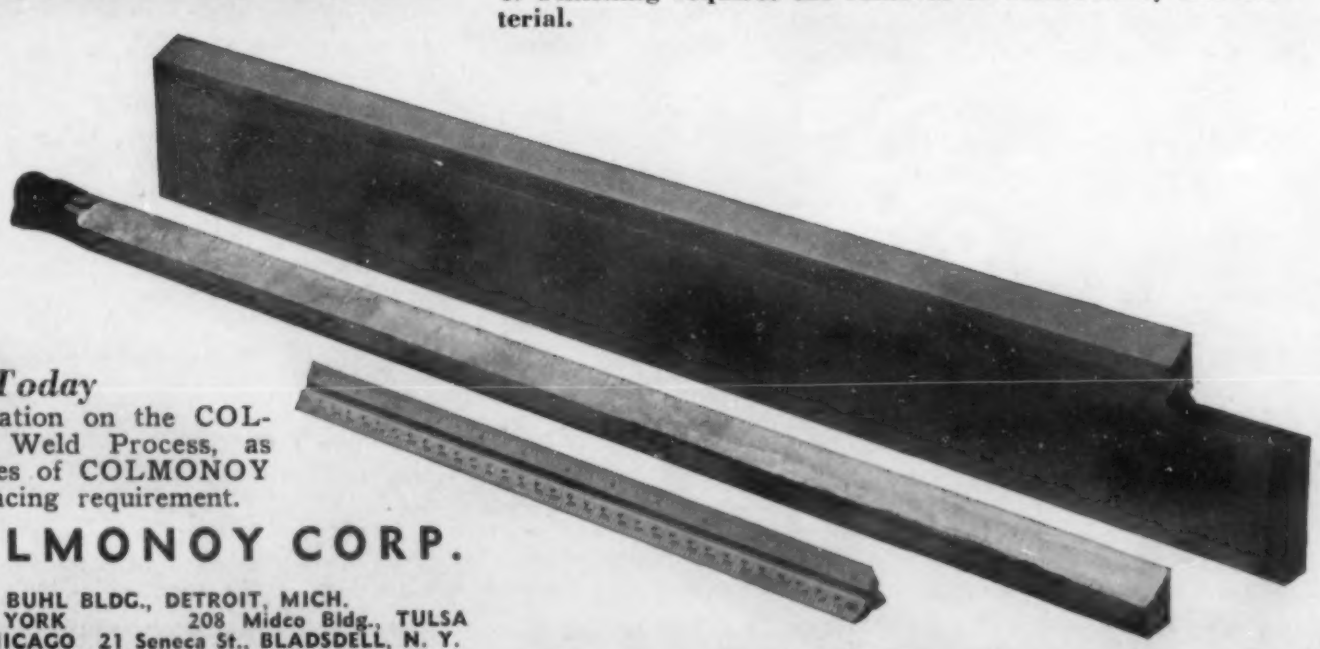

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books

FOR METALLURGICAL ENGINEERS

Foundrymen's Dogs

IRON MEN AND THEIR DOGS. *By Ferdinand C. Latrobe. Published by Koppers Co., Bartlett Hayward Div., Pittsburgh, Pa. (may be purchased from The Horn-Shafer Co., 3 E. Redwood St., Baltimore, Md.) 1941. Cloth, 6¾ x 9¾ in., 225 pages. Price $4.50.*

This is a book about a foundry and about a pair of dogs, progenitors of the Chesapeake Bay retriever. Incidentally, it would be hard to select a reviewer more favorably disposed to hunting dogs or more likely to be specially interested in an account of dogs belonging to workers in metallurgical fields than the present one.

The case in hand is not the only one of a combination of metallurgical and canine interests.

A Sir Robert Dudley (1573-1649), Duke of Northumberland and Earl of Warwick, is credited with being the first to teach spaniels to "set" birds, *i.e.* to point. From selected spaniels that had acquired pointing ability the English setter was developed. Other records allege that it was an earlier Robert, Duke of Northumberland, and the specific year in which the dog was successfully trained is given as 1555.

A more or less distant cousin, Edward, Lord Dudley, the 9th Baron, (1567-1643) was an ironmaster in the days when Admiralty needs for timber necessitated conservation of and substitution for charcoal. Edward had coal pits on his property and found that he could use coal instead of charcoal to smelt iron. He was granted a "Patent", *i.e.* a monopoly, for this discovery which was held so important that when James I abolished the grants of monopoly, this one to Lord Dudley was excepted. Dud Dudley, son of Lord Dudley, published in 1665 one of the earliest papers on metallurgical technology, describing the reduction of ore by coal.

The development of smelting technique and that of hunting dogs were not due to the same individual, but both the Dudley lines stem back to the 5th Baron, so it's all in the family.

A more recent combination of scientist and fancier of hunting dogs occurred in Dr. E. F. Northrup of high-frequency furnace fame, whose avocation was breeding and training pointers.

The dogs of the present book are two Newfoundland puppies rescued from a foundering British brig, bound from Newfoundland for England, by the master of the ship *Canton*. The dog, Sailor, was given to John Mercer of Anne Arundel County who sold him to Governor Edward Lloyd. Sailor, bred to spaniels and coon dogs, produced pups that by selective breeding developed into the "Eastern Sho' " Chesapeake Bay retriever. The bitch, Canton, was given to James Stewart of Sparrow's Point and, similarly crossed, gave rise to the Western Shore strain.

Natural selection of the Eastern and Western Shore strains resulted in astonishingly similar dogs with the water-resistant coat and the hardiness of the present day Chesapeake so that in 1877 the breed was officially recognized as established and able to reproduce strictly to type. Thus the two Newfoundlands, Canton and Sailor, are the fountain heads of the Chesapeake.

In the late 1830's George and Jonas Hayward of New Hampshire came to Baltimore and entered the business of making cast iron stoves, followed by hot water heating systems, cast iron store fronts and other architectural castings. In this era cast iron animal statues were popular as lawn ornaments so the firm (now become Hayward-Bartlett and Co., by the addition of another New Englander, Bartlett, whose son-in-law was an active breeder of Chesapeakes), quite as interested in duck hunting as in the foundry, cast carefuly modelled statues of Canton and Sailor to stand at the office doorway as mascots, to indicate that the stamina of the Chesapeake was analogous to the quality of their products.

That taking time to hunt and to train hunting dogs is a brain-clearing procedure that makes for business efficiency was thoroughly believed by the founders and adhered to by succeeding executives of the Bartlett-Hayward Co., now the Bartlett-Hayward Div. of Koppers Co., which still proudly advertises its admiration for the descendants of Canton and Sailor.

The bulk of the book deals with the branching out of the firm into manufacture of gas holders, heavy castings for dam construction, gun carriages, and the like through the past century. The last chapter, however, reverts to a description of Chesapeake Bay duck hunting of olden times, plus a rhapsody on the terrapin.

As a historical study of the growth of a modern engineering firm from small foundry beginnings, the book would be of real interest to most anyone, doubly so to metallurgical engineers, and in even greater measure to those who combine such interests with a love of hunting and hunting dogs.

—H. W. GILLETT

Mechanical Engineers' Handbook

MECHANICAL ENGINEERS' HANDBOOK. 4TH EDITION. *Edited by Lionel S. Marks. Published by McGraw-Hill Book Co., Inc., New York, 1941. Cloth, 5 x 7¼ in., 2274 pages. Price $7.00.*

"Marks' Handbook" is one of the few handbooks that belong on the metallurgical engineer's bookshelf, alongside his Metals Handbook. Metallurgical engineering today is so much broader than metallurgy that all kinds of mechanical, electrical, materials and chemical information must supplement the metallurgical engineer's basic fund of knowledge on the constitution, structure and physical properties of metals in various conditions.

Marks' Handbook supplies this need with respect to "mechanical" information and also provides the mechanical engineer with enough immediately useful metallurgical information for most of his normal needs. The book contains 16 sections, the following being of the most interest from the metallurgical engineering viewpoint: Sec. 5, Mechanical Properties of Materials; Sec. 6, Materials of Engineering; Sec. 7, Fuels and Furnaces; Sec. 8, Machine Elements; and Sec. 13, Machine Shop Practice.

B. R. Queneau, C. W. Briggs, Cyril Smith, H. S. Rawdon, M. H. Mawhinney, H. R. Stansel, J. M. Lessells, G. B. Karelitz, C. W. Ham, E. V. Crane, Wm. Spraragen, and O. W. Boston are among the authorities whose names at the heads of certain sections lend assurance of the authenticity of the metallurgical engineering information presented.

—FRED P. PETERS

Other New Books

PHOTO-MICROGRAPHY. *By R. M. Allen. Published by D. Van Nostrand Co., Inc., New York, 1941. Cloth, 6¼ x 9¼ in., 365 pages. Price $5.50.* Discusses fundamentals, with emphasis on medical, biological and similar work. An excellent treatise on its broad topic, but only about 7 pages of direct interest to metallographers.

FATIGUE OF METALS—SOME FACTS FOR THE DESIGNING ENGINEER. *Published by Nitralloy Corp., New York, 1941. Paper, 6 x 9 in., 45 pages.* Free to those interested. A very useful, well-written engineering discussion of fatigue stresses and appropriate design therefor.